SALMON AND STEELHEAD HABITAT LIMITING FACTORS

WATER RESOURCE INVENTORY AREA 27

WASHINGTON STATE
CONSERVATION COMMISSION

FINAL REPORT

Gary Wade

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Dan Dupuis (Fish First)
Dick Dyrland (Friends of the East Fork; Fish First)
Jim Fisher (Private Fisheries Consultant)
Donna Hale (WDFW Fisheries Biologist)
Shane Hawkins (WDFW Fisheries Biologist)
Daryl Hodges (USFS Gifford Pinchot Fisheries Biologist)
Darin Houpt (Cowlitz/Wahkiakum Conservation District)
Dave Howard (WDOE)
Jack Kaeding (Fish First)
Sam Kolb (WDFW Habitat Biologist)
Erik Lesko (PacifiCorp Fisheries Biologist)
Steve Manlow (WDFW Habitat Biologist)
Rick Marlowe (DNR Forest Practices Forester)
Fred Palmer (Kalama Sportsman's Club)
Dan Rawding (WDFW Fisheries Biologist)
Ron Roler (WDFW Fisheries Biologist)
Ed Smith (Clark/Skamania Flyfishers)
Jim Stolarzyk (Cowlitz/Wahkiakum Conservation District)
Dean Sutherland (Clark Public Utilities)
Dean Swanson (Friends of the East Fork; Fish First)
Don Swanson (Friends of the East Fork; Fish First)
John Tyler (Clark County Community Development)
Chris Wagemann (WDFW Kalama River Research Center)

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EXECUTIVE SUMMARY

Introduction

Section 10 of Engrossed Substitute House Bill 2496 (Salmon Recovery Act of 1998), directs the Washington State Conservation Commission, in consultation with local government and treaty tribes to invite private, federal, state, tribal, and local government personnel with appropriate expertise to convene as a Technical Advisory Group (TAG). The purpose of the TAG is to identify habitat limiting factors for salmonids. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon, including all species of the family Salmonidae." The bill further clarifies the definition by stating "These factors are primarily fish passage barriers and degraded estuarine areas, riparian corridors, stream channels, and wetlands." It is important to note that the responsibilities given to the Conservation Commission in ESHB 2496 do not constitute a full limiting factors analysis. This report is based on a combination of existing watershed studies and knowledge of the TAG participants.

WRIA 27 is located in Southwest Washington within portions of Skamania, Clark, and Cowlitz Counties, and it includes three major watersheds; the Kalama River, the Lewis River (North Fork), and the East Fork Lewis River (see Map Appendix A-1). All river systems within WRIA 27 drain to the Columbia River. Six stocks of anadromous salmon and steelhead return to the rivers. For purposes of this analysis the WRIA was separated into four subbasins, lower and upper Lewis River (below and above the dams), East Fork Lewis, and Kalama.

WRIA 27 Habitat Limiting Factors

The major habitat limiting factors that were common to all streams within WRIA 27 included:

- Almost throughout WRIA 27, LWD abundance was below the habitat standards. Adequate large woody debris in streams, particularly larger key pieces, is critical to developing pools, collecting spawning gravels, and providing habitat diversity and cover for salmonids.
- Riparian conditions were also poor within most of the basins. Loss of riparian function affects water quality, erosion rates, streambank stability, and instream habitat conditions.
- Water quality, especially high water temperatures, was identified as a major limiting factor within certain subbasins of WRIA 27.
- Water quantity was also identified as a limiting factor almost throughout WRIA 27. Both low flows that limit the rearing habitat and access and increased peak flows that alter instream habitat were considered significant problems in many of the subbasins.
- Most of the historic off-channel and floodplain habitat has been disconnected from the river by diking and hardening the channels. Loss of these off-channel habitats limits rearing and over-wintering habitat for juvenile salmonids.

WRIA 27 Recommendations for Addressing Limiting Factors

- Develop or revise and update land use ordinances that are meant to protect critical habitat for threatened and endangered species;
- Protect and enhance riparian habitat with sufficiently sized buffers and speed recruitment of conifers to increase the potential future supply of LWD;
- Supplement LWD within productive tributaries after careful consideration of the hydraulics and suitability of the site;
- Continue to identify ways to reduce water temperatures, increase water quality, augment minimum streamflows, and replace passage barriers within WRIA 27;

Kalama River Habitat Limiting Factors

Approximately 96% of the Kalama watershed is in commercial forestry and owned by private companies. During the 1970's, almost the entire watershed, including the riparian zones, was logged, most of the instream LWD debris was removed, and an extensive system of roads was constructed. The resultant loss of riparian function and instream LWD, and the alterations in hydrology have left many subbasins with poor habitat conditions for salmonids.

Most of the historic floodplain has been diked and disconnected from the river to protect highway and industrial development; further degrading already naturally limited rearing and over-wintering habitat for juvenile coho. A wide and shallow bar continues to grow at the mouth of the Kalama, where predation and excessive water temperatures is likely limiting fish passage. Coarse sediments have accumulated at the mouths of many tributaries, limiting access and rearing habitat during low flows, and fine sediments have embedded spawning substrates in areas of the mainstem Kalama.

Recommendations for addressing limiting factors include:

- Assess and then develop solutions to conditions on the Kalama River bar, and to the extensive deposits of coarse sediments that have accumulated in tributary mouths;
- Increase and/or enhance off-channel and rearing habitat within the Kalama River;
- Continue to monitor and repair or decommission roads;
- Seek agreements to minimize the amount of timber harvest occurring within the basin at any one time to maintain hydrologic maturity and minimize peak flows.

Critical habitats that need protection include:

- Fall chinook, chum spawning grounds in the lower mainstem;
- Winter steelhead spawning and rearing habitat in the mainstem above the lower falls;
- Lower river tributaries and off-channel rearing areas for coho salmon;
- The five most productive tributaries for summer steelhead (Gobar, Wildhorse, Langdon, and Lakeview Peak creeks, and the North Fork Kalama).

Lewis River Habitat Limiting Factors

The main habitat limiting factor on the Lewis river is the system of dams that block passage to 80% of the historic anadromous habitat. Flow regimes and ramping rates have been set to protect a healthy run of native fall chinook downstream of the dams, but revisions may need to be made to protect other ESA listed stocks. Most of the lower floodplain has been diked and disconnected from the river, limiting rearing habitat for juvenile salmonids. Riparian conditions and LWD abundance were considered poor in most areas within the basin.

A large tributary, Cedar Creek provides the majority of spawning rearing habitat left in the Lewis River system for steelhead and coho. Major factors limiting habitat within Cedar Creek include elevated water temperatures, low summer flows, and spawning gravels cemented with fine sediments.

Small populations of native adfluvial bull trout/Dolly Varden are found above the dams in the reservoirs and in Cougar, Rush, and Pine creeks. Limiting factors include excessive fine sediment, loss of riparian habitat, and elevated stream temperatures from the eruption of Mt. Saint Helens, logging, and road construction.

Recommendations for addressing limiting factors in the Lewis River include:
- Continue to look for ways to reintroduce anadromous fish above the dams;
- Increase and/or enhance off-channel and rearing habitat within the lower Lewis River and within Cedar Creek;
- Reduce fine sediment inputs to Cedar Creek and its tributaries;
- Look for ways to reduce water temperatures and augment low flows within the Cedar Creek basin.

Some of the most critical habitats in need of protection include:
- The Cedar Creek basin provides most of the spawning and rearing habitat for coho, and steelhead within the Lewis River;
- Protection of the native fall chinook spawning grounds and juvenile rearing areas is considered critical;
- Rush, Cougar, and Pine creeks provide the only spawning habitat for bull trout.

East Fork River Habitat Limiting Factors

Large portions of the upper East Fork watershed repeatedly burned during the first half of the century. The watershed is slowly recovering; however, these disturbances have had significant impacts on the hydrology, the structure, composition, and age-class distribution of the plant communities, as well as riparian and instream habitats.

Elevated water temperatures are considered a major problem in many tributaries and especially within the lower East Fork. The recent avulsion of the East Fork into abandoned gravel pits increased already high rates of erosion and channel instability in the lower river and led to a significant loss in spawning habitat for fall chinook. Diking and development within the floodplain has largely disconnected the river and reduced over-winter habitat and low flows appear to limit the amount of available rearing habitat in the summer for juvenile salmon and steelhead.

Recommendations for addressing limiting factors in the East Fork Lewis River include:

- Assess changes in bank and channel stability, erosion rates, water quality, and predation rates resulting from the recent avulsion into the Ridgefield Pits, and look for both short-and long-term solutions that will help restore the habitat;
- Continue efforts to reduce water temperatures and improve overall water quality, and to augment flow during low-flow periods;
- Reconnect and enhance limited off-channel and floodplain habitat;

Some of the most critical habitats in need of protection include:

- The lower 10 miles of the East Fork provides most of the limited floodplain habitat that remains within WRIA 27, and critical fall chinook and chum spawning habitat;
- Rock Creek (upper) and the mainstem above Sunset Falls provide the most critical winter and summer steelhead spawning and rearing habitat in the East Fork basin.

Data Gaps

The ability to determine what factors are limiting salmonid production, and to prioritize those factors within and between subbasins is limited by the current lack of specific habitat assessment data. Collecting this baseline data will be critical for developing effective recovery plans, for prioritizing future recovery efforts, and for monitoring the success of those efforts. The significant data gaps in WRIA 27 include:

- Watershed level processes such as hydrology, sediment transport and storage, nutrient cycling, vegetation composition and structure;
- Recent and comprehensive data on the distribution and condition of stocks;
- Physical surveys of habitat conditions within most of the tributary streams;
- Comprehensive water quality data from all major subbasins;
- Minimum flow requirements and water quality standards that are based on the needs of anadromous salmonids.

The following chapters provide a detailed assessment of the habitat limiting factors by subbasin for WRIA 27.

INTRODUCTION

Habitat Limiting Factors Background

The successful recovery of naturally spawning salmon populations depends upon directing actions simultaneously at harvest, hatcheries, habitat and hydro, the 4H's. The1998 state legislative session produced a number of bills aimed at salmon recovery. Engrossed Substitute House Bill (ESHB) 2496 is a key piece of the 1998 Legislature's salmon recovery effort, with the focus directed at salmon habitat issues. Engrossed Substitute House Bill (ESHB) 2496 in part:

> directs the Conservation Commission in consultation with local government and the tribes to invite private, federal, state, tribal and local government personnel with appropriate expertise to act as a technical advisory group; directs the technical advisory group to identify limiting factors for salmonids to respond to the limiting factors relating to habitat pursuant to section 8 sub 2 of this act; defines limiting factors as "conditions that limit the ability of habitat to fully sustain populations of salmon." defines salmon as all members of the family salmonidae, which are capable of self-sustaining, natural production.

The overall goal of the Conservation Commission's limiting factors project is to identify habitat factors limiting production of salmonids in the state. At this time, the report identifies habitat limiting factors pertaining to salmon, steelhead trout and include bull trout when they share the same waters with salmon and steelhead. Later, we will add bull trout-only waters, as well as specific factors that relate to cutthroat.

It is important to note that the responsibilities given to the Conservation Commission in ESHB 2496 do not constitute a full limiting factors analysis. The hatchery, hydro and harvest segments of identifying limiting factors are being dealt with in other forums.

The Role of Habitat in a Healthy Population of Natural Spawning Salmon

During the last 10,000 years, Washington State anadromous salmonid populations have evolved in their specific habitats (Miller 1965). Water chemistry, flow, and the physical stream components unique to each stream have helped shape the characteristics of every salmon population. These unique physical attributes have resulted in a wide variety of distinct salmon stocks for each salmon species throughout the State. Within a given species, stocks are population units that do not extensively interbreed because returning adults rely on a stream's unique chemical and physical characteristics to guide them to their natal grounds to spawn. This maintains the separation of stocks during reproduction, thus preserving the distinctiveness of each stock.

Throughout the salmon's life cycle, the dependence between the stream and a stock continues. Adults spawn in areas near their own origin because survival favors those that do. The timing of juveniles leaving the river and entering the estuary is tied to high natural river flows. It has been theorized that the faster speed during out-migration reduces predation on the young salmon and perhaps is coincident to favorable feeding conditions in the estuary (Wetherall 1971). These are a few examples that illustrate how a salmon stock and its environment are intertwined throughout the entire life cycle.

Salmon habitat includes the physical, chemical and biological components of the environment that support salmon. Within freshwater and estuarine environments, these components include water quality, water quantity or flows, stream and river physical features, riparian zones, upland terrestrial conditions, and ecosystem interactions as they pertain to habitat. However, these components closely intertwine. Low stream flows can alter water quality by increasing temperatures and decreasing the amount of available dissolved oxygen, while concentrating toxic materials. Water quality can impact stream conditions through heavy sediment loads, which result in a corresponding increase in channel instability and decrease in spawning success. The riparian zone interacts with the stream environment, providing nutrients and a food web base, woody debris for habitat and flow control (stream features), filtering runoff prior to surface water entry (water quality), and providing shade to aid in water temperature control.

Salmon habitat includes clean, cool, well-oxygenated water flowing at a normal (natural) rate for all stages of freshwater life. In addition, salmon survival depends upon specific habitat needs for egg incubation, juvenile rearing, migration of juveniles to saltwater, estuary rearing, ocean rearing, adult migration to spawning areas, and spawning. These specific needs can vary by species and even by stock.

When adults return to spawn, they not only need adequate flows and water quality, but also unimpeded passage to their natal grounds. They need deep pools with vegetative cover and instream structures such as root wads for resting and shelter from predators. Successful spawning and incubation depend on sufficient gravel of the right size for that particular population, in addition to the constant need of adequate flows and water quality, all in unison at the necessary location. Also, delayed upstream migration can be critical. After entering freshwater, most salmon have a limited time to migrate and spawn, in some cases, as little as 2-3 weeks. Delays can results in pre-spawning mortality, or spawning in a sub-optimum location.

After spawning, the eggs need stable gravel that is not choked with sediment. River channel stability is vital at this life history stage. Floods have their greatest impact to salmon populations during incubation, and flood impacts are worsened by human activities. In a natural river system, the upland areas are forested, and the trees and their roots store precipitation, which slows the rate of storm water into the stream. The natural, healthy river is sinuous and contains large pieces of wood contributed by an intact, mature riparian zone. Both slow the speed of water downstream. Natural systems have floodplains that are connected directly to the river at many points, allowing wetlands to store flood water and later discharge this storage back to the river during lower flows. In a healthy river, erosion or sediment input is great enough to provide new gravel for spawning and incubation, but does not overwhelm the system, raising the riverbed and increasing channel instability. A stable incubation environment is essential for salmon, but is a complex function of nearly all habitat components contained within that river ecosystem.

Once the young fry emerge from the gravel nests, certain species such as chum, pink, and some chinook salmon quickly migrate downstream to the estuary. Other species, such as coho, steelhead, bull trout, and chinook, will search for suitable rearing habitat within the side sloughs and channels, tributaries, and spring-fed "seep" areas, as well as the outer edges of the stream. These quiet-water side margin and off channel slough areas are vital for early juvenile habitat. The presence of woody debris and overhead cover aid in food and nutrient inputs as well as provide protection from predators. For most of these species, juveniles use this type of habitat in the spring. Most sockeye populations migrate from their gravel nests quickly to larger lake environments where they have unique habitat requirements. These include water quality sufficient to produce the necessary complex food web to support one to three years of salmon growth in that lake habitat prior to outmigration to the estuary.

As growth continues, the juvenile salmon (parr) move away from the quiet shallow areas to deeper, faster areas of the stream. These include coho, steelhead, bull trout, and certain chinook. For some of these species, this movement is coincident with the summer low flows. Low flows constrain salmon production for stocks that rear within the stream. In non-glacial streams, summer flows are maintained by precipitation, connectivity to wetland discharges, and groundwater inputs. Reductions in these inputs will reduce that amount of habitat; hence the number of salmon dependent on adequate summer flows.

In the fall, juvenile salmon that remain in freshwater begin to move out of the mainstems, and again, off-channel habitat becomes important. During the winter, coho, steelhead, bull trout, and remaining chinook parr require habitat to sustain their growth and protect them from predators and winter flows. Wetlands, stream habitat protected from the effects of high flows, and pools with overhead are important habitat components during this time.

Except for bull trout and resident steelhead, juvenile parr convert to smolts as they migrate downstream towards the estuary. Again, flows are critical, and food and shelter are necessary. The natural flow regime in each river is unique, and has shaped the population’s characteristics through adaptation over the last 10,000 years. Because of the close inter-relationship between a salmon stock and its stream, survival of the stock depends heavily on natural flow patterns.

The estuary provides an ideal area for rapid growth, and some salmon species are heavily dependent on estuaries, particularly chinook, chum, and to a lesser extent, pink salmon. Estuaries contain new food sources to support the rapid growth of salmon smolts, but adequate natural habitat must exist to support the detritus-based food web, such as eelgrass beds, mudflats, and salt marshes. Also, the processes that contribute nutrients and woody debris to these environments must be maintained to provide cover from predators and to sustain the food web. Common disruptions to these habitats include dikes, bulkheads, dredging and filling activities, pollution, and alteration of downstream components such as lack of woody debris and sediment transport.

All salmonid species need adequate flow and water quality, spawning riffles and pools, a functional riparian zone, and upland conditions that favor stability, but some of these specific needs vary by species, such as preferred spawning areas and gravel. Although some overlap occurs, different salmon species within a river are often staggered in their use of a particular type of habitat. Some are staggered in time, and others are separated by distance.

Chum and pink salmon use the streams the least amount of time. Washington adult pink salmon typically begin to enter the rivers in August and spawn in September and October, although Dungeness summer pinks enter and spawn a month earlier (WDFW and WWTIT 1994). During these times, low flows and associated high temperatures and low dissolved oxygen can be problems. Other disrupted habitat components, such as less frequent and shallow pools from sediment inputs and lack of canopy from an altered riparian zone or widened river channel, can worsen these flow and water quality problems because there are fewer refuges for the adults to hold prior to spawning. Pink salmon fry emerge from their gravel nests around March and migrate downstream to the estuary within a month. After a limited rearing time in the estuary, pink salmon migrate to the ocean for a little over a year, until the next spawning cycle. Most pink salmon stocks in Washington return to the rivers only in odd years. The exception is the Snohomish Basin, which supports both even- and odd-year pink salmon stocks.

In Washington, adult chum salmon (3-5 years old) have three major run types. Summer chum adults enter the rivers in August and September, and spawn in September and October. Fall chum adults enter the rivers in late October through November, and spawn in November and December. Winter chum adults enter from December through January and spawn from January through February. Chum salmon fry emerge from the nests in March and April, and quickly outmigrate to the estuary for rearing. In the estuary, juvenile chum follow prey availability. In Hood Canal, juveniles that arrive in the estuary in February and March migrate rapidly offshore. This migration rate decreases in May and June as levels of zooplankton increase. Later as the food supply dwindles, chum move offshore and switch diets (Simenstad and Salo 1982). Both chum and pink salmon have similar habitat needs such as unimpeded access to spawning habitat, a stable incubation environment, favorable downstream migration conditions (adequate flows in the spring), and because they rely heavily on the estuary for growth, good estuary habitat is essential.

Chinook salmon have three major run types in Washington State. Spring chinook are generally in their natal rivers throughout the calendar year. Adults begin river entry as early as February in the Chehalis, but in Puget Sound, entry doesn’t begin until April or May. Spring chinook spawn from July through September and typically spawn in the headwater areas where higher gradient habitat exists. Incubation continues throughout the autumn and winter, and generally requires more time for the eggs to develop into fry because of the colder temperatures in the headwater areas. Fry begin to leave the gravel nests in February through early March. After a short rearing period in the shallow side margins and sloughs, all Puget Sound and coastal spring chinook stocks have juveniles that begin to leave the rivers to the estuary throughout spring and into summer (August).

Within a given Puget Sound stock, it is not uncommon for other chinook juveniles to remain in the river for another year before leaving as yearlings, so that a wide variety of outmigration strategies are used by these stocks. The juveniles of spring chinook salmon stocks in the Columbia Basin exhibit some distinct juvenile life history characteristics. Generally, these stocks remain in the basin for a full year. However, some stocks migrate downstream from their natal tributaries in the fall and early winter into larger rivers, including the Columbia River, where they are believed to over-winter prior to outmigration the next spring as yearling smolts.

Adult summer chinook begin river entry as early as June in the Columbia, but not until August in Puget Sound. They generally spawn in September and/or October. Fall chinook stocks range in spawn timing from late September through December. All Washington summer and fall chinook stocks have juveniles that incubate in the gravel until January through early March, and outmigration downstream to the estuaries occurs over a broad time period (January through August). A few of these stocks have a component of juveniles that remain in freshwater for a full year after emerging from the gravel nests.

While some emerging chinook salmon fry outmigrate quickly, most inhabit the shallow side margins and side sloughs for up to two months. Then, some gradually move into the faster water areas of the stream to rear, while others outmigrate to the estuary. Most summer and fall chinook outmigrate within their first year of life, but a few stocks (Snohomish summer chinook, Snohomish fall chinook, upper Columbia summer chinook) have juveniles that remain in the river for an additional year, similar to many spring chinook (Marshall et al. 1995). However, those in the upper Columbia, have scale patterns that suggest that they rear in a reservoir-like environment (mainstem Columbia upstream from a dam) rather than in their natal streams and it is unknown whether this is a result of dam influence or whether it is a natural pattern.

The onset of coho salmon spawning is tied to the first significant fall freshet. They typically enter freshwater from September to early December, but has been observed as early as late July and as late as mid-January (WDF et al. 1993). They often mill near the river mouths or in lower river pools until freshets occur. Spawning usually occurs between November and early February, but is sometimes as early as mid-October and can extend into March. Spawning typically occurs in tributaries and sedimentation in these tributaries can be a problem, suffocating eggs. As chinook salmon fry exit the shallow low-velocity rearing areas, coho fry enter the same areas for the same purpose. As they grow, juveniles move into faster water and disperse into tributaries and areas which adults cannot access (Neave 1949). Pool habitat is important not only for returning adults, but for all stages of juvenile development. Preferred pool habitat includes deep pools with riparian cover and woody debris.

All coho juveniles remain in the river for a full year after leaving the gravel nests, but during the summer after early rearing, low flows can lead to problems such as a physical reduction of available habitat, increased stranding, decreased dissolved oxygen, increased temperature, and increased predation. Juvenile coho are highly territorial and can occupy the same area for a long period of time (Hoar 1958). The abundance of coho can be limited by the number of suitable territories available (Larkin 1977). Streams with more structure (logs, undercut banks, etc.) support more coho (Scrivener and Andersen 1982), not only because they provide more territories (useable habitat), but they also provide more food and cover. There is a positive correlation between their primary diet of insect material in stomachs and the extent the stream was overgrown with vegetation (Chapman 1965). In addition, the leaf litter in the fall contributes to aquatic insect production (Meehan et al. 1977).

In the autumn as the temperatures decrease, juvenile coho move into deeper pools, hide under logs, tree roots, and undercut banks (Hartman 1965). The fall freshets redistribute them (Scarlett and Cederholm 1984), and over-wintering generally occurs in available side channels, spring-fed ponds, and other off-channel sites to avoid winter floods (Peterson 1980). The lack of side channels and small tributaries may limit coho survival (Cederholm and Scarlett 1981). As coho juveniles grow into yearlings, they become more predatory on other salmonids. Coho begin to leave the river a full year after emerging from their gravel nests with the peak outmigration occurring in early May. Coho use estuaries primarily for interim food while they adjust physiologically to saltwater.

Sockeye salmon have a wide variety of life history patterns, including landlocked populations of kokanee which never enter saltwater. Of the populations that migrate to sea, adult freshwater entry varies from spring for the Quinault stock, summer for Ozette, to summer for Columbia River stocks, and summer and fall for Puget Sound stocks. Spawning ranges from September through February, depending on the stock.

WATERSHED CONDITION

General Description

Located along the Columbia River in Southwest Washington, Water Resource Inventory Area (WRIA) 27 covers 839,010 acres in portions of three counties (Clark, Cowlitz, and Skamania) (see WRIA 27 Location Map: Appendix A-1). WRIA 27 contains three major drainages; the Kalama River, the North Fork Lewis River, and the East Fork Lewis River. The Kalama River and the Lewis River flow into the Columbia River at river mile (RM) 73.1 and RM 87 respectively. The Lewis River watershed includes two large drainages, the North Fork and East Fork, which converge approximately 3.5 miles upriver from the confluence with the Columbia River.

Land Ownership

Land ownership within WRIA 27 is a mixture of private, state, federal, and local government. (see Table 1: Percentage of Watershed in Landowner Categories and WRIA 27 Public Lands Map: Appendix A-2). Approximately 44 percent of the watershed is managed by the Gifford Pinchot National Forest. Other large landowners include Washington State Department of Natural Resources, Weyerhauser Company, Plum Creek Timber Company, Longview Fiber Company, Pacificorp, and Hampton Timber Company. Major urban areas within WRIA 27 include Woodland, Kalama, Cougar, Yacolt, Chelatchie, Amboy, LaCenter, and Ridgefield (WDFW 1998, vol 1). Portions of the WRIA have experienced rapid population growth and industrial development over the last 20 years. For example, Clark County has experienced a threefold increase in population within the un-incorporated areas since 1960 (Hutton, 1995b).

Land Uses

The majority of WRIA 27 is forested and managed for commercial forest products. Other land uses include commercial farming in the Woodland Bottoms and other valley areas, industrial sites along the Columbia River, residential areas, gravel mining, hydroelectric plants, wilderness areas, parks and open space reserves, and fish hatcheries. Recreational use of public lands within WRIA 27 is extensive. The Mt. Saint Helens visitor center alone received an average of 2,000,000 visitors each season over the past six years (USFS 1999b). Some of the recreational activities include hiking, fishing, hunting, cross-country skiing, kayaking, and driving just for pleasure. Road densities range from zero to over ten miles of road per square mile of land (WDFW 1998, vol 1 appendices) (see Table 2).

Climate

The WRIA's climate is maritime, with mild, cool, wet winters and dry, warm summers. Orographic effects in the region are pronounced, with average annual precipitation totals that vary from 45 inches near Woodland to over 140 inches near Mt. Adams (WDFW 1998, vol. 1). Snowfall makes up a large proportion of the precipitation at higher elevations. (Hutton 1995b).

Table 1: Percentage of Watershed in Landowner Categories

Landowner	Acres	Percent
National Forest (Wilderness 2%)	326,564	39
Mt. St. Helens National Volcanic Monument	39,746	5
Department of Natural Resources	88,844	11
Private		
Weyerhauser	100,000	12
Plum Creek Timber	35,000	4
Longview Fiber	15,000	2
International Paper	2,500	<1
Pacificorp	10,000	1
Other	219,396	26
US Fish & Wildlife Service	647	<1
Bureau of Land Management	66	<1
WDFW	299	<1
WA State Parks	233	<1
City and County	686	<1
Unknown	57	<1
Total	*839,010*	*100*

Adapted from WDFW Vol. 1, 1998

Table 2: Road Densities in WRIA 27

Unit	Kalama	North Fork (to Merwin)	East Fork:
Basin Area (sq. miles)	224.5	189.41	236.16
Road Miles	1292.26	848.87	975.95
Road Density (miles/sq. mile)	*5.75*	*4.48*	*4.13*

(Lewis County GIS 1999)

Topography

The topography within WRIA 27 varies from essentially flat in the Woodland Bottoms to the steep slopes of Mt. Saint Helens and Mt. Adams (see Table 3). Elevation above sea level ranges from approximately 10 feet where the Lewis and Kalama Rivers enter the Columbia River to 12,267 feet on the summit of Mt. Adams (see Table 4).

Table 3: Percent of WRIA 27 in Slope Categories

Slope Category %	Percent of WRIA
0-5	14.8
6-27	48.3
28-49	25.6
50-70	9.8
71-100	1.5
Total	*100.0*

Adapted from WDFW Vol. 1, 1998

Table 4: Percent of WRIA 27 in Elevation Categories

Elevation Category (feet)	Percent of WRIA 27
0-200	4.5
201-1,000	20.7
1,001-4,000	67.4
> 4,000	7.4
Total	*100.0*

Adapted from WDFW Vol. 1, 1998

Kalama River

The Kalama River begins on the southwest slope of Mt. Saint Helens and flows 44.5 miles west-southwest to enter the Columbia River at river mile (RM) 73.1 (WDW 1990). While the river's headwaters arise in Skamania County, 98.9 percent of the 205 square mile drainage area is within Cowlitz County.

Topography is mountainous, averaging 1,880 feet, and climaxing near 8,000 feet on Mt. Saint Helens. Much of the landscape was formed over the last 20,000 years as a result of Mt. Saint Helens' volcanic activity occurring at intervals of 100 to 400 years (USFS 1996a). Lahars (mudflows) from St Helens traveled down many of the Kalama basin's drainages, leaving unconsolidated volcanic deposits that have a tendency to erode on steep slopes (USFS 1996a). This is a concern in the upper portions of the Kalama and some of its tributaries, where steep slopes increase the possibility of mass wasting (see Mass Wasting and Stream-Floodplain Connections Map in Appendix A-4).

The gradient of the Kalama River along the lower 8 miles is flat to moderate. At the mouth, a shallow bar that inhibits fish passage at low tide extends well into the Columbia (WDF 1951). Tidal influences extend up to approximately Modrow Bridge at RM 2.8. At RM 10, the lower Kalama Falls blocked most anadromous passage other than summer steelhead until it was laddered in 1936 and then improved in the 1950s. A concrete barrier dam and fish ladder at the falls now traps most returning fish and only steelhead and excess spring chinook are passed above the lower falls by the WDFW (Wagemann 1999, personal comm.). Above RM 10 the valley closes in and continues as a narrow V-shaped drainage (WDW 1990). At RM 35 an impassable falls blocks all anadromous passage. Many of the tributaries to the Kalama have steep gradients, with only the lower portions of the streams accessible to anadromous fish (see Historic Anadromous Distribution with Passage Barriers Map Appendix A-3).

Approximately 96 percent of the Kalama River Watershed is owned and managed by private timber companies. Most of the watershed was logged in the 1960s through the early 1980s; current timber harvest is minimal in comparison (WDFW 1998, vol. 1). An extensive road network (1292 miles of roads) covers the forestry lands, with a road density of 5.75 miles/square mile of area (Lewis County GIS 1999). Even in the upper Kalama watershed on Forest Service property road densities often exceed 4.0

miles/square mile (USFS 1996a). Extensive industrial development has occurred within the historic floodplains in the lower 2 miles of the Kalama, especially to the west of Interstate-5. Most of the lower river has been channelized and diked to facilitate this development. Residential development has increased along the lower river as well.

Mean flow in the Kalama subbasin for 1953 through 1967 was 1,219 cubic feet per second (cfs) (WDW 1990). Because much of the subbasin is below the normal snow line, peak river flows correspond to mid-winter warm rains and possible snowmelt from the foothills (see Table 5). Low flows are generally encountered in the late summer and fall (WDW 1990).

Table 5: Kalama Subbasin Flows (cfs) and Temperatures (F)

Month	Flow (cfs)	Temp (F)	Month	Flow (cfs)	Temp (F)
January	2,152	39.7	July	409	56.5
February	1,954	39.7	August	305	56.7
March	1,702	42.1	September	306	54.3
April	1,566	46.0	October	680	50.5
May	1,063	50.5	November	1,645	45.9
June	688	54.1	December	2,157	41.9
			Average	*1,219*	*48.2*

Flows (1953-1967) and temperatures (1960 – 1967) measured below Italian Creek. Adapted from WDW 1990.

A 1974 survey found that land use within the Kalama subbasin is dominated by forestry (see Table 6) (USFS 1996a). Creation of the legislative and administrative Mt. Saint Helens National Volcanic Monument has subsequently reduced acreage in commercial forest. With the exception of the upper headwaters and other scattered tracts, the Kalama subbasin is privately owned. The only urban area in the Kalama subbasin is the town of Kalama near the mouth of the river.

Table 6: Land Use (%) in Kalama Subbasin

Land Use	Percent
Commercial Forest	96.0
Non-Commercial Forest	1.3
Cropland	1.5
Other	1.1

Prior to active state and federal regulation of forest practices, fishery habitat was damaged throughout the Kalama subbasin. Indiscriminate logging around and through streams, the use of splash dams to transport logs, and poor road construction and inadequate culverts reduced or eliminated anadromous fish from many streams (WDW 1990). Most of the private timberlands were logged in the 1970s and early 1980s, leading to excessive peak flows carrying high sediment loads. The construction of

Interstate-5 and development near the mouth has reduced already limited floodplain habitat within the lower river.

Lower Lewis River (to Merwin Dam)

The Lewis River watershed is approximately 93 miles long, has a total fall of approximately 12,000 feet, and drains an area of about 1,050 square miles (EA Engineering 1999). The headwaters arise on the southern flanks of Mt. Saint Helens and Mt. Adams. The mainstem of the Lewis, also known as the North Fork, flows southwesterly from its source in Skamania County through three impoundments, Swift Reservoir (River Mile 47.9), Yale Reservoir (34.2), and Merwin Lake (RM 19.5). The middle and lower sections of the North Fork Lewis form the boundary between Clark and Cowlitz Counties. A major tributary, the East Fork Lewis River, enters the mainstem at RM 3.5. From this point the mainstem Lewis flows westerly, entering the Columbia River at RM 88. The average annual streamflow for the entire Lewis River system is approximately 6,125 cubic feet per second (cfs). For analysis purposes, this report divides the watershed into the North Fork (mainstem) Lewis River and East Fork Lewis River.

Upper Lewis River (above Merwin Dam)

The North Fork Lewis River headwaters arise from the southern flanks of Mt. Adams and Mt. Saint Helens in the Cascade Range. The lower 12 miles of the mainstem and North Fork Lewis River flows through a wide flat valley, much of which is under cultivation and protected from flooding by dikes. The lower 11 miles are a tidally influenced backwater of the Columbia River. Within this area, the flow is sluggish and the sediments are generally composed of sand, silts, and clays typical of lower floodplains. The valley begins to narrow for the next 8 miles, eventually forming a canyon from the confluence of Cedar Creek (RM 15.7) to Merwin Dam (WDF, 1990). The 240 foot high Merwin Dam (RM 20) is a major feature on the river, blocking all upstream passage to 80% of the historical anadromous habitat. This is the first of three dams blocking passage on the Lewis River

Before these dams were completed, salmon and steelhead production was the result of natural spawning, with major production of coho, spring chinook, fall chinook, and winter and summer steelhead (see WRIA 27 Historic Anadromous Distribution with Passage Barriers Map in Appendix A-3). Mitigation programs have attempted to reestablish these runs, but pre-dam productivity of the Lewis River is unknown (WDF 1990).

The majority of the Lewis River basin is forested, typical of the southern Washington Cascade Mountains. However, an area of approximately 30 square miles within the upper basin was denuded by the May 18, 1980 eruption of Mt. Saint Helens (EA Engineering 1999). Most of the basin is within the western hemlock vegetation zone (Franklin and Dyrness 1973).

A large portion of the North Fork Lewis River basin is managed as commercial forest and, as such, is undeveloped except for logging roads. However, recreational use and residential development demand has increased significantly (EA Engineering 1999; WDFW 1998, vol. 1). Road densities in the basin range from 4.96 miles/square mile in the lower North Fork below Merwin Dam (Lewis County GIS 1999) to as low as 2.01 miles/square mile in the upper portions of the watershed on Forest Service lands (USFS 1995c). Population densities are generally low within the basin. There is scattered residential development with only a few small communities (Cougar, Chelatchie, and Amboy) in the upper basin. The largest urban population center, the City of Woodland, lies near the mouth of the river.

The major tributaries within the Lewis River system below Merwin Dam include the East Fork Lewis River, Johnson Creek, and Cedar Creek. Now that the dams block anadromous passage to the upper river, Cedar Creek provides most of the productive tributary habitat for anadromous salmonids within the North Fork basin. Cedar Creek has a number of tributaries with productive anadromous salmonid habitat including Pup Creek, Bitter Creek, Beaver Creek, and North and South Forks of Chelatchie Creek (see WRIA 27 Historic Anadromous Distribution Map in Appendix A-3). The mainstem of the North Fork, from RM 15 to the Merwin Dam (RM 20) provides an extremely productive spawning area for fall chinook. All three reservoirs (Merwin, Yale, and Swift) have populations of bull trout/Dolly Varden. Three streams provide rearing and spawning habitat for bull trout in the upper river including Pine and Rush Creeks that flow into Swift Reservoir, and Cougar Creek that flows into Yale Reservoir (see Bull Trout/Dolly Varden Distribution Map in Appendix A-11).

The average annual stream discharge for the North Fork Lewis is 4,900 cubic feet per second. Glacial runoff contributes to the flow in the Lewis River, but rainfall provides the most significant contribution (WDF, 1973). Management of the flow in the Lewis is largely controlled through the Merwin Project licensing agreement with the operator of the dam, PacifiCorp. Since 1985, PacifiCorp and the Washington Departments of Fisheries (WDF) and of Wildlife (WDW) have studied the relationship between spring flows and chinook rearing habitat on the North Fork and evaluated the need to modify spring flow provisions in Article 49 of the licensing agreement. In 1995, Article 49 was amended to provide for increased minimum flows of 2700 cfs in April, May, and June (WDFW Vol. 1 Appendices, 1998). The need for additional modifications of flow regimes and ramping rates to protect other ESA listed or proposed for listing species (steelhead, chum salmon, coho salmon, and cutthroat trout) will be assessed as part of the ongoing relicensing studies (Lesko 1999, personal comm.).

East Fork Lewis River

The East Fork watershed extends approximately 11 miles into Skamania County and the Gifford Pinchot National Forest near Green Lookout Mountain, and reaches an elevation of approximately 4442 feet above sea level. It joins the North Fork of the Lewis River approximately 4000 feet downstream from the Interstate 5 bridge, where the elevation of the riverbed is four feet below mean sea level (see Figure 1 from Hutton 1995b).

At its headwaters, the East Fork Lewis River generally flows through steep, mountainous terrain, restricted by narrow valley walls. Tributary streams in the headwaters are steep channels dominated by bedrock and boulders. The two largest tributaries in the upper East Fork Lewis River basin are Copper and upper Rock creeks (R2 Resources, 1999). Lucia Falls (RM 21.3) is thought to block upstream migration for all anadromous species other than steelhead and an occasional coho (WDF, 1990). From Lucia Falls downstream to river mile 17 near the mouth of Rock Creek (lower), the East Fork is within a narrow ravine where water velocities are such that the stream is slowly down cutting. Upstream from Lewisville Park at river mile 14, the river cuts through volcanic ash, pyroclastic layers, and basalt lava flows creating waterfalls, small gorges, and cliffs. Downstream from river mile 17 and especially below river mile 11, the valley floor begins to broaden out into a well-defined flood plain. The East Fork's gradient declines from approximately 20 feet per mile, at RM 11, to less than 2 feet per mile at RM 6. Bedload deposition occurs in this section in the form of gravel bars where declining gradient and loss of energy releases gravel, causing bar formation, channel shifting, and increased susceptibility to flooding. Most of the remaining six miles of river is less than ten feet above mean sea level, has minimal slope, and is subject to backwater effects from the Columbia (Hutton 1995b).

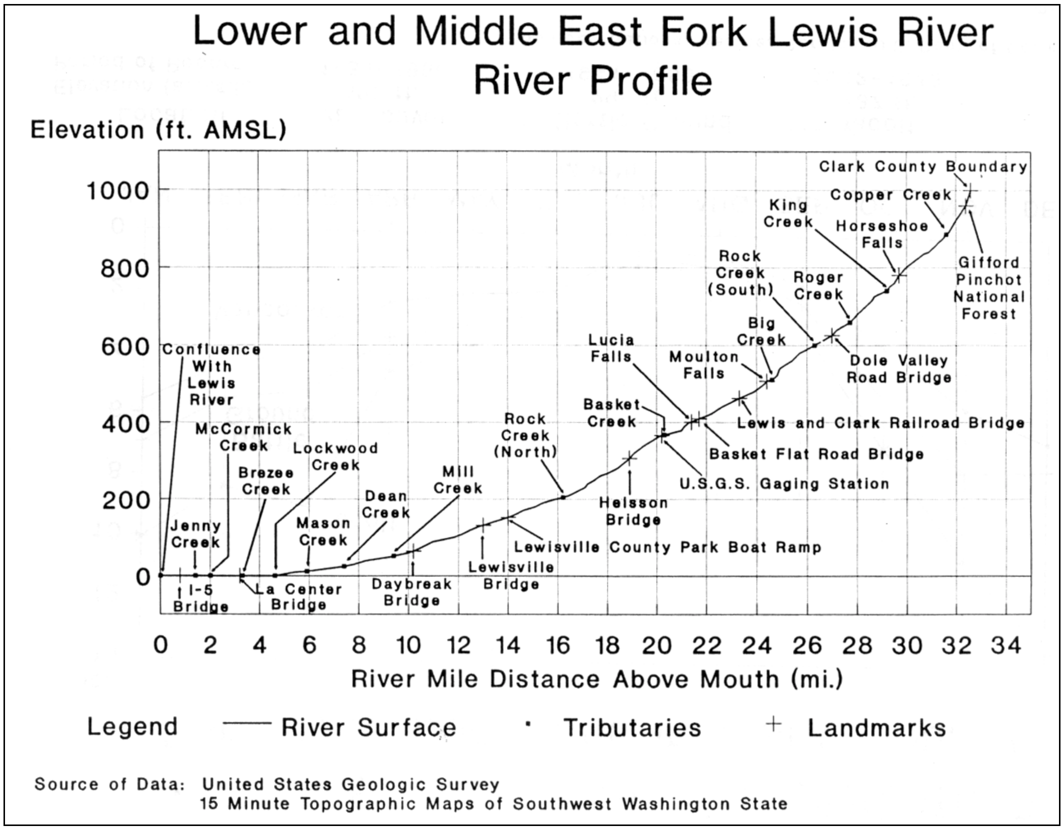
The East Fork of the Lewis River contributes, on average, approximately 1000 cubic feet per second to the flow of the Columbia River (Hutton 1995b). Rainfall provides the most significant contribution to streamflow in the basin (USFS 1995a). Therefore, streamflows are substantially higher during the rainy season, from November to April than from May through October. Overbank flooding can be severe in the lower sections of the East Fork (Hutton 1995b).

Despite extensive residential development, forestry and farming are still the predominate land-use even in the lower portions of the watershed (Hutton 1995c). In general, the upper portions of the watershed contain mainly large private and public holdings actively managed for timber production. Approximately 56 percent of the upper East Fork Watershed is owned and managed by private timber companies, 23 percent by the Washington State Department of Natural Resources (DNR), and 23 percent by the U.S. Forest Service (USFS 1995a).

Just below Daybreak Park (RM 10) are a number of abandoned gravel mining pits. During November 1995, the East Fork avulsed (abruptly changed channels) through a gravel pit pond at RM 9 and abandoned about 1,700 ft of channel. In November of 1996, the river again avulsed through 6 closely spaced gravel pit ponds called the Ridgefield Pits from RM 8.3 to RM 7.6 (see Figure 2 from Norman et al. 1998). The avulsion into these ponds has created highly dynamic and unstable conditions within the lower reaches of the East Fork. Wetlands and open-water also covers large areas of the floodplains within this lower stretch of the river. La Center, Washington is the only heavily urbanized area on the main stem of the East Fork.

Repeated large-scale stand-replacement fires burned large portions of the eastern portions of Clark County between 1902 and 1952, and these disturbances have had significant impacts on the hydrology, the structure, composition, and age-class distribution of the plant communities, as well as riparian and instream habitats along the East Fork system.

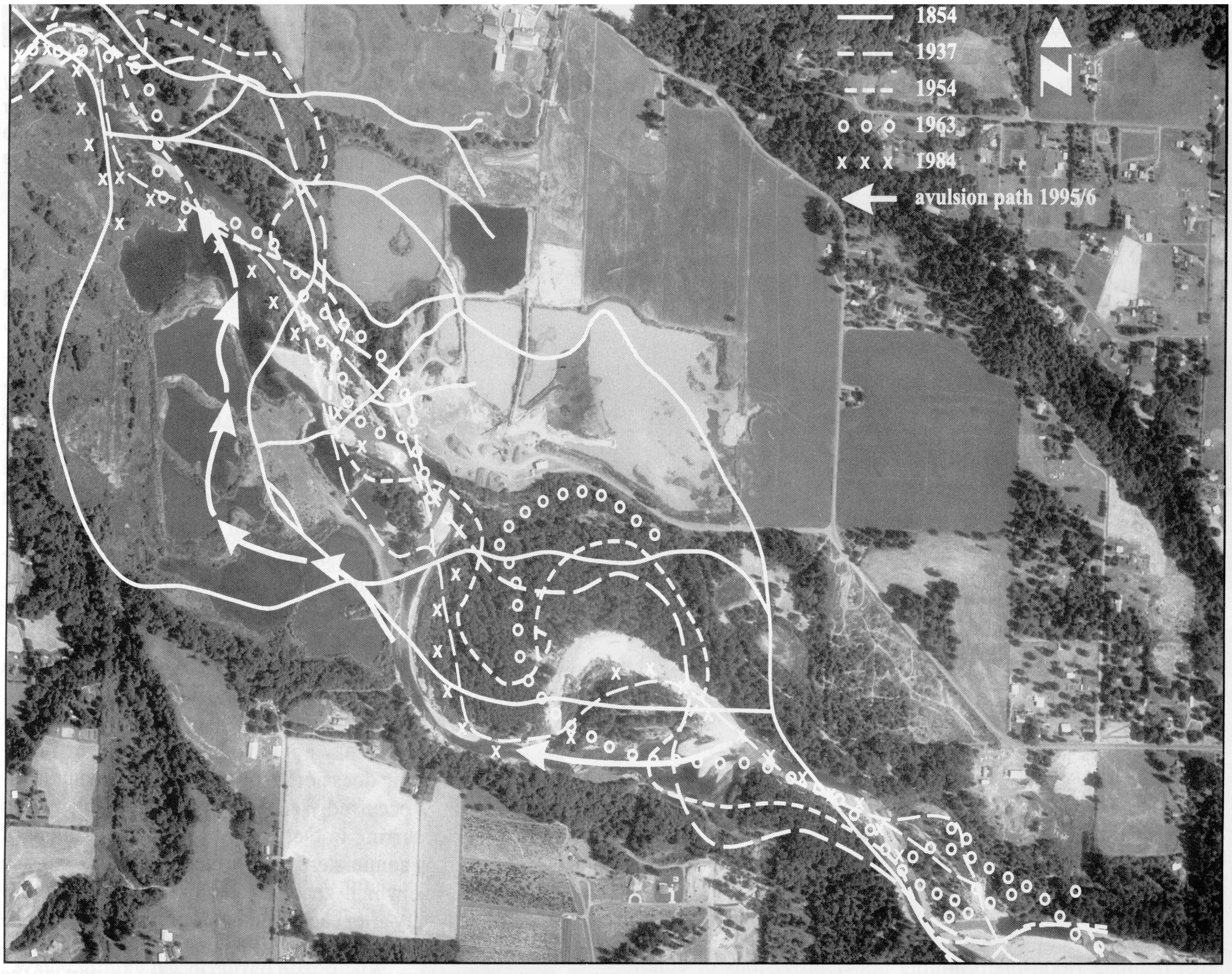
Figure 1: Profile of the Lower and Middle East Fork Lewis River



Adapted from Hutton 1995b

The largest fire, the Yacolt Burn, occurred in 1902 and covered an estimated 238,900 acres of state, private, and federal lands extending from the foothills of the Cascades. Fires repeatedly burned over the portions of the same area, including the Rock Creek Fire of 1927 (48,000 acres), and the Dole Fire of 1929 (227,500 acres). Some areas have burned over five times, with the last major fires occurring in 1952 (USFS 1995a). Besides destroying most if not all of the vegetation within the burned areas, these fires were especially hot. Portions of the higher peaks and ridges burned so hot that shrub/forb seral stages still predominate (USFS 1995a).

Figure 2: East Fork Lewis River Historic Channel Locations



Aerial photo (1996) showing the paths of abandoned river channels from the 1995/1996 avulsion and older channel scars. Adapted from Norman et al. 1998

Sediment loading, high stream temperatures, insufficient canopy cover, large peak flows, and soil productivity were probably at their worst soon after the large fires. The major flood events occurring in 1931 and 1934 were probably associated with rain-on-snow precipitation events that coincided with major fires (USFS 1995a). Natural processes are slowly healing the landscape, and many of the associated problems have decreased in severity. However, snag habitat, number of pieces of large woody debris per mile of stream, and the vegetation structure, composition, and age-class distribution remain well outside of historic conditions today, and are projected to remain outside historic conditions well into the future.

DISTRIBUTION AND CONDITION OF STOCK

The distribution of fall and spring chinook salmon, winter and summer steelhead, coho salmon, chum salmon, and Dolly Varden/bull trout was mapped within WRIA 27 at a 1:24,000 scale for this Habitat Limiting Factors Analysis. Maps for each of the anadromous species of interest were developed using a number of existing sources on distribution, such as SASSI, Streamnet, WDFW stream surveys, and WDFW spawning surveys (see Map Appendix A). Members of the Technical Advisory Group (TAG) for WRIA 27 added considerably to this existing database with professional experience on WRIA 27 stream systems. For each species, known, presumed, and potential habitat was mapped (see Appendix C: Fish Distribution Definitions). Table 7 (WRIA 27 Fish Distribution and Barriers) represents a compilation of all the fish distribution data that was collected for each stream as well as the number of miles of stream affected by physical barriers.

Table 7: WRIA 27 Fish Distribution and Barriers

Stream	**Species Present**							**Miles of Use**			**Physical Barriers (Miles Affected)**		
	SC	*FC*	*WS*	*SS*	*CH*	*CO*	*BT*	*KN*	*PR*	*POT*	*Dikes*	*Culverts*	*Dams*
Lower Lewis River*	x	x	x	x	x	x		20.4			7.4		
Gee Creek			x			x			6.0				
Allen Canyon Creek			x			x			0.5				
Lower E. F. Lewis *		x	x	x	x	x		21.2			6.5		
McCormick Creek			x			x			0.9	2.3		2.3	
(1) Brezee Creek			x			x		.4		5.7		5.7	
(2) Brezee Creek			x			x						5.6	
(3) Brezee Creek			x			x						0.3	
(4) Brezee Trib			x			x						1.8	
Lockwood Creek			x			x		*2.2*	*4.6*	*2.3*	*0.4*	*1.2*	
Riley Creek			x			x		*2.9*		*0.8*		*0.8*	
Mason Creek			x			x		*6.3*	*2.7*				
Mason Trib								*1.4*	*0.6*			*1.1*	
Mason Trib												*0.47*	
Dean Creek			x			x		1.6	0.7			2.2	
Dean Creek			x			x						0.8	
Manley Creek			x			x		1.0	0.8				
Mill Creek			x			x		2.0	0.5				
Rock Creek (Lower)			x			x		*4.5*	*1.4*				
Unnamed			x			x				1.8			
Upper East Fork *			x	x				18.5	1.0				
Big Tree Creek			x	x					1.5	0.23		0.23	
Rock Creek			x	x				5.6	3.3				
Cedar Creek			x	x				4.5					
Cold Creek			x	x				0.7					
Coyote Creek			x	x				1.2					
King Creek			x	x				.5	1.8				
Copper Creek			x	x				.4					
Slide Creek			x	x				1.5					
Green Fork			x	x				1.6		0.3		0.3	
Robinson Creek			x	x		x		.9					
Ross Creek			x	x		x			2.3				
Houghton Creek			x	x		x		1.6	0.6				
Johnson Creek			x	x		x		1.0					
Cedar Creek	x	x	x	x	x	x		20.2		1.4		1.4	
Pup Creek			x	x		x		2.0					
(1)Beaver Cr.			x	x		x		0.1		1.4		1.4	
(2)Beaver Cr.			x	x		x						0.88	

Stream	Species Present							Miles of Use			Physical Barriers (Miles Affected)		
	SC	*FC*	*WS*	*SS*	*CH*	*CO*	*BT*	*KN*	*PR*	*POT*	*Dikes*	*Culverts*	*Dams*
(3)Beaver Cr.			x	x		x						0.73	
John Creek			x	x		x			0.3	0.8		0.8	
Brush Creek			x	x		x			0.2	0.9		0.9	
Bitter Creek			x	x		x		*1.4*					
Unnamed Trib.			x			x		0.1		1.5		1.5	
Chelatchie Cr.		x	x	x		x		4.8					
NF Chelatchie Cr.		x	x	x		x		1.3					
Upper N. F. Lewis*	x	x	x	x		x	x			53.3			53.3
Dog Creek			x	x		x	x			2.0			
Panamaker Creek			x	x		x	x			2.1			
Cougar Creek			x	x		x	x			1.4			
Swift Creek			x	x		x	x			2.8			
Marble Creek			x	x		x	x			1.4			
Range Creek			x	x		x	x			1.9			
Drift Creek			x	x		x	x			7.7			
Pine Creek			x	x		x	x			2.2			
Muddy River			x	x		x	x			15.9			
Clearwater Creek			x	x		x	x			3.5			
Clear Creek			x	x		x	x			8.7			
Rush Creek			x	x		x	x			2.5			
Schoolhouse Creek						x			*0.3*	*3.2*		*3.2*	
Bybee Creek						x			*0.4*	*1.0*		*1.0*	
Lower Kalama Riv.	x	x	x	x	x	x		10.5			2.8		
Spencer Creek			x			x		1.3					
Cedar Creek			x			x		0.8					
Hatchery Creek			x			x		0.2	2.7				
Indian Creek			x					0.2					
Upper Kalama Riv.	x		x	x	x	x		26.3	1.1				
Little Kalama River			x	x				3.2					
Dee Creek			x	x				0.8					
Summers Creek			x	x				0.1					
Knowlton Creek			x	x				0.3					
Wildhorse Creek			x	x				2.4	1.8	0.6		0.6	
Gobar Creek			x	x				6.0	4.1				
Bear Creek			x	x				1.8		0.3		0.3	
Arnold Creek			x	x				1.9	1.9				
Unnamed Creek			x	x					1.3				
Jacks Creek			x	x				1.7					
Lost Creek			x	x					0.7				
Elk Creek			x	x				0.4					
Bush Creek			x	x					0.9				
Wolf Creek			x	x				1					
Langdon Creek			x	x				1.6					
North Fork Kalama			x	x				3.1	5.6				
Lakeview Peak Cr.			x	x				3.4					

SC= Spring Chinook FC= Fall Chinook KN= Known Presence
WS= Winter Steelhead SS= Summer Steelhead PR= Presumed Presence
CH= Chum CO= Coho POT= Potential Presence
BT= Bull Trout
*Lower Lewis River from Mouth to Merwin Dam *Lower East Fork from Mouth to Lucia Falls (21.3)
*Upper East Fork from Lucia Falls to Headwaters *Lower Kalama from Mouth to Lower Kalama Falls (RM 10)
*Upper Kalama from Lower Kalama Falls to Upper Kalama Falls (RM 36.8)

Winter Steelhead Distribution was used to denote miles of Known, Presumed, and Potential habitat except where coho salmon distribution was greater. The numbers were italicized where coho distribution was used.

Spring Chinook (*Oncorhynchus tshawytscha*)

Spring and fall chinook are indigenous to the Lewis and Kalama systems. Historically, spring chinook were predominant in the Lewis River and fall chinook in the Kalama basin. By the early 1900's, Columbia river salmon populations were declining from overfishing and a combination of land use practices that proved detrimental to salmon habitat (WDFW, 1998 vol. 1). The construction of Merwin Dam in 1931 blocked all anadromous passage at RM 20 and virtually eliminated the natural run of spring chinook in the Lewis system. Approximately 80% of the available anadromous fish habitat was blocked by the construction of Merwin Dam (WDF/WDW 1993).

Early attempts to save the native population through hatchery production failed, and by the 1950's spring chinook runs in both the Lewis and Kalama rivers had been reduced to only remnant populations. In 1951, Washington Department of Fisheries estimated the escapement of spring chinook in the Lewis River at only 100 fish (WDF 1951). Nearly all of the spawning on the Lewis River occurs in a 4-mile reach from Merwin Dam downstream to the Lewis River hatchery (WDF/WDW 1993). Hatchery programs for spring chinook were established at Kalama Falls Hatchery after its completion in 1959 and at Speelyai and Lewis River hatcheries beginning in 1971.

The Lewis River naturally spawning spring chinook population was considered healthy based on escapement trend (see Table 8) (WDF/WDW 1993). However, Myers et al. (1998) indicate the possibility that the native Lewis River spring chinook run is extinct, and the observed stock has undergone extensive hybridization. This information conflicts with the 1993 SASSI report (WDF/WDW 1993) that lists the Lewis River spring chinook stock as native (see Table 9). Additional information is needed to determine the stock origin and recent stock status for Lewis River spring chinook (Rawding 1999). Natural spawn escapement from 1980-1991 has averaged 2,194 with a low of 345 in 1981 and a peak of 6,939 in 1987. Only occasional stray spring chinook return to the East Fork Lewis (WDF/WDW 1993).

The Kalama River spring chinook stock status was also considered healthy based on escapement trends but shows signs of a short-term severe decline (see Table 8) (WDF/WDW 1993). However, this status was determined on a mixed stock of composite production, and WDFW is not sure of the recent status of wild Kalama spring chinook populations (Rawding 1999). Escapement from 1980-1991 averaged 602 with a low of zero in 1985 and a peak of 2,892 in 1982 (WDF and WDW, 1993). Primary production is from hatchery releases.

Spawning occurs between the Lower Kalama Hatchery (RM 4.8) and the Kalama Falls Hatchery (RM 10). In surplus years, spawning releases are made upstream of the upper hatchery, allowing access all the way to the upper falls (RM 36) (Caldwell et al. 1999).

Table 8 - WRIA 27 Spring Chinook Stock Status

Stock	Screening Criteria	1992 SASSI Stock Status	Status (ESA Listing)
Kalama	Escapement Trend	Healthy	Federal "Threatened"
NF Lewis	Escapement Trend	Healthy	Federal "Threatened"
EF Lewis	None	None	Federal "Threatened"

Adopted from WDF/WDW 1993

Table 9 - WRIA 27 Spring Chinook Stocks

Stock	Stock Origin	Production Type
Kalama	Mixed	Composite
NF Lewis	Native	Wild
EF Lewis		

Adopted from WDF/WDW 1993

Fall Chinook (*Oncorhynchus tshawytscha*)

Since the early 1900's natural fall chinook populations have been stable or increasing in the Lewis River (WDFW 1998, vol. 1 appendices). The North Fork Lewis River fall chinook represent about 80% to 85 % of the wild fall chinook returning to the Lower Columbia River (WDF, 1990). In 1951, Lewis River fall chinook escapement was estimated at 5,000 fish.

The Lewis River fall chinook natural spawners are a native stock of wild production (see Table 11). The stock has been supplemented from time to time by Kalama stock since 1940, but no fall chinook have been planted in the basin since 1986 (WDF/WDW 1993). The stock of wild fall chinook in the Lewis River system has maintained a significant population with negligible hatchery influences, unlike other lower Columbia River stocks (WDF/WDW, 1993). There is now a self-sustaining population with an escapement goal of 5,700 adults (Dammer 2000, personal comm.).

North Fork Lewis River fall chinook spawn in the area from Merwin Dam down to Lewis River Salmon Hatchery, a distance of approximately 4 miles. McIssac (1990) states that construction of Merwin Dam eliminated approximately half the fall chinook spawning habitat which would place the historical upper limits of fall chinook migration to approximately Yale dam (in PacifiCorp 1999). The North Fork Lewis River fall chinook natural spawn stock status was considered healthy based on escapement trend (see Table 10). Natural spawn escapements from 1967-1991 averaged 12,976 with a low return of 4,199 in 1976 and a peak of 22,977 in 1989 (WDF/WDW 1993).

East Fork Lewis River fall chinook spawn in the area from Lucia Falls down to below Daybreak Park near RM 6.2 (Hawkins 1999, personal comm.). Spawning surveys for fall chinook regularly occur between Lewisville Park (RM 15) and Daybreak Park (RM 10). The East Fork Lewis River fall chinook spawners are a native stock. The stock status was considered healthy based on escapement trend in 1992 (see Table 10). However, the health of the stock status is unknown today (Hawkins 1999, personal comm.). Natural spawn escapements from 1967-1991 averaged 598 with a low return of 157 in 1987 and a peak return of 2,354 in 1971 (WDF/WDW, 1993).

Historically, fall chinook in the Kalama River system were abundant. For many years a fish trapping and canning operation existed about one-mile from the river's mouth (WDF 1951). Natural production of fall chinook in the Kalama River has declined from historic levels and has been replaced by hatchery fish (WDFW 1998, vol. 1 appendices). Run size prior to hatchery plants is difficult to determine because the Lower Kalama Salmon Hatchery began operation in 1895 when 4 million eggs were taken (WDF/WDW 1993). In 1951, Washington Department of Fisheries estimated spawning escapement at 20,000 fall chinook. The mainstem Kalama between Lower Kalama Falls (RM 10) and to around Modrow Bridge (RM 2.4) provides the entire available spawning habitat for fall chinook populations in the Kalama basin.

The Kalama River stock status was considered healthy based on escapement trend (see Table 10) (WDF/WDW 1993). However, this status was determined on a mixed stock with composite production, and WDFW is not sure of the recent status of wild Kalama fall chinook populations (Rawding 1999). Natural spawn escapements from 1967-1991 averaged 6,448 with a low return of 1,259 in 1985 and a peak of 24,549 in 1988 (WDF/WDW 1993).

Table 10 - WRIA 27 Fall Chinook Stock Status

Stock	**Screening Criteria**	**1992 SASSI Stock Status**	**Status (ESA Listing)**
Kalama	Escapement Trend	Healthy	Federal "Threatened"
NF Lewis	Escapement Trend	Healthy	Federal "Threatened"
EF Lewis	Escapement Trend	Healthy	Federal "Threatened"

Adopted from WDF and WDW, 1993

Table 11 - WRIA 27 Fall Chinook Stocks

Stock	**Stock Origin**	**Production Type**
Kalama	Mixed	Composite
NF Lewis	Native	Wild
EF Lewis	Native	Wild

Adopted from WDF and WDW, 1993

Coho Salmon (*Oncorhynchus kisutch*)

Historically, the Lewis River system had abundant wild coho. At one time coho were present in the Lewis River all the way to the headwater tributaries of Pine Creek at river mile (rm) 59.0 and the Muddy River (rm 60.0), including Clearwater and Clear Creeks (WDF/WDW 1993) (see Map A-3: Historic Anadromous Distribution with Passage Barriers Map Appendix A). In 1949, Bryant described the Lewis River as one of the most important coho producers in the Columbia Basin. In 1951, WDF estimated that 15,000 coho entered the Lewis River system to spawn, with 10,000 entering the North Fork and 5,000 the East Fork (WDF/WDW 1993). After construction of Merwin Dam in 1931, but before Yale Dam was built, coho were trapped and transported to the Merwin Reservoir to use upstream habitats. After Yale Dam was constructed, spawning and rearing habitats were flooded. Downstream passage for juveniles became impractical and transportation was discontinued (WDFW 1998, vol. 1 appendices). Lucia Falls (RM 21.3) is the upstream terminus for coho migrations in the East Fork Lewis (WDF/WDW 1993).

Coho in the Lewis watershed are managed for hatchery production, but some returning fish will successfully use natural habitat (WDFW 1998, vol. 1 appendices). Cedar Creek is the most extensively used stream on the North Fork Lewis; with coho traveling 15 miles into tributaries like the North and South Forks of Chelatchie Creek (WDF 1973). Coho stock status in the North Fork Lewis is considered depressed based on a long-term decline in escapement (see Table 12) (WDF/WDW 1993). Historically, mainly late returning coho utilized the East Fork, while both late and early returning coho were found in the North Fork. SASSI (WDF/WDW 1993) lists East Fork coho stock status as depressed. The recent status of coho within the East Fork Lewis is unknown because of incomplete and inconsistent survey data; however, the limited information that is available suggests that the population is depressed (Shane Hawkins 1999, personal comm.).

Coho were historically present in the Kalama basin but not in great abundance; the Washington Department of Fisheries (1951) estimated about 3,000 fish. Both early-returning and late-returning fish were present, but distribution was confined to the area below Kalama Falls (RM 10.0) until a fish ladder was constructed in 1936. Coho from the Lower Kalama Hatchery have been released in the basin since at least 1942 (WDFW 1998, vol. 1).

The Kalama River coho stock status is depressed based on chronically low production (see Table 12). Natural spawning is presumed to be quite low and subsequent juvenile production is considered below stream potential. The current management policy on the Kalama River is to not pass coho the lower Kalama Falls (RM10), and the only tributaries that provide good coho production potential are Hatchery (Fallert), Spencer Creek, and Cedar Creek (Dammers 2000, personal comm.)

Table 12 - WRIA 27 Coho Stock Status

Stock	Screening Criteria	1992 SASSI Stock Status	Status (ESA Listing)
Kalama	Chronically Low	Depressed	Federal “Candidate”
NF Lewis	Chronically Low	Depressed	Federal “Candidate”
EF Lewis	Chronically Low	Depressed	Federal “Candidate”

Adapted from WDF/WDW 1993

Summer Steelhead (*Oncorhynchus mykiss)*

Summer steelhead are indigenous to the Lewis River watershed. Construction of Merwin Dam blocked anadromous fish passage to approximately 80% of the useable spawning and rearing habitat within the North Fork Lewis watershed (WDF/WDW, 1993). Passage was also blocked by a mill dam on Cedar Creek until the dam was removed in 1946. Spawning now occurs throughout most of Cedar Creek. Summer steelhead spawn throughout most of the East Fork Lewis River also. Few steelhead were reported to have ascended Sunset Falls on the East Fork Lewis (RM 32.7) before it was notched in 1982 to facilitate fish passage. Now approximately 12% of the observed spawning in the East Fork occurs in the headwaters above Sunset Falls and in the upper tributaries (WDFW 1998, vol. 1 appendices).

Total escapement of summer steelhead to the Lewis River between 1925 and 1933 was estimated to be 4,000 fish, while the average run size 1963-1967 was estimated to be 6,150 (WDF 1990). No total estimates are available for the historical wild component of summer steelhead with the exception of 1984 when the East Fork wild component was estimated to be about 600 fish while estimates of the North Fork were less than 50 fish (WDF 1990). More recent escapement data is displayed in Table 15 (LCSCI 1998).

The wild stock of North Fork summer steelhead is chronically low in abundance and rated as depressed due to loss of access to available habitat upstream of the dams (see Table 13). Wild summer steelhead returns account for less than 7% of the total North Fork run size (WDFW 1998, vol. 1 appendices). Due to low return of wild summer steelhead to the North Fork, no escapement goal has been established (LCSCI 1998). The East Fork summer steelhead stock status was classified as unknown in the 1992 SASSI (WDF/WDW, 1993). With more recent information, East Fork summer steelhead are now considered "depressed" due to chronically low escapements (see Table 13). The East Fork Lewis River summer-run steelhead stock is primarily comprised of non-native hatchery origin fish, with some natural spawning (WDF 1990). The hatchery fish originate Skamania, Washougal and Klickitat hatchery brood stocks (Wageman 1999, personal comm.). Historically, an average of approximately 90,000 summer-run steelhead smolts were released annually into the East Fork Lewis River system, although current stocking is around 40,000 smolts (Rawding 1999 in R2 Resources 1999: Appendix A).

Table 13 - WRIA 27 Summer Steelhead Stock Status

Stock	Screening Criteria	Proposed 1997 Stock Status	Status (ESA Listing)
Kalama	Short-Term Severe Decline	Depressed	Federal "Threatened"
EF Lewis	Chronically Low	Depressed	Federal "Threatened"
NF Lewis	Chronically Low	Depressed	Federal "Threatened"

Adapted from Lower Columbia Steelhead Conservation Initiative, 1998

Table 14 - WRIA 27 Summer Steelhead Stocks

Stock	Stock Origin	Production Type	Data Type	Escapement	Monitoring Period
Kalama	Native	Wild	Trap	Total	1977-1997
EF Lewis	Native	Wild	Snorkel	Index	1995-1997
NF Lewis	Native	Wild			Not Monitored

Adapted from Lower Columbia Steelhead Conservation Initiative, 1998

Table 15 - WRIA 27 Summer Steelhead Escapement Data

Stock	Wild Steelhead Escapement Goal	1991-1996 Average Wild Steelhead Escapement	Average % of Wild Escapement Goals	Average % of Hatchery Spawners
Kalama	1000	1170	117%	64%
EF Lewis	512	85 I	<30%	71%
NF Lewis	Not set	NA	NA	

Adapted from Lower Columbia Steelhead Conservation Initiative, 1998

The Kalama River subbasin historically had moderate numbers of summer steelhead. Run size of natural fish in the 1950's was probably less than 1,500 (WDW 1990). Distribution was throughout the watershed up to the high falls at RM 35. Summer steelhead were thought to be the only salmonids to regularly move beyond the Kalama Falls Hatchery site before the construction of the fishway in 1936 (WDW 1990). The current status of the Kalama River summer steelhead stock is depressed based upon adjusted trap count data collected by WDFW's Kalama River Research Station personnel. The escapement goal is 1,000 wild summer steelhead (WDF/WDW 1993; LCSCI 1998).

Winter Steelhead (*Oncorhynchus mykiss*)

Estimates of the historical spawning escapement of winter steelhead before Merwin Dam range from a low of 1,000 (Smoker et al. 1951) up to 11,000 (Lavoy 1983). Today, there is limited wild steelhead production in the North Fork, and the majority of the spawning and rearing habitat for winter steelhead in the Lewis River watershed is found in the East Fork basin (WDFW 1998, vol. 1 appendices).

As partial mitigation for the lost spawning and rearing habitat, state hatcheries began planting winter steelhead smolts in the Lewis in 1954 (WDFW 1998, vol. 1 appendices). The Lewis River winter steelhead stocks are now composed of both wild and hatchery stocks. Lucas (1985- in WDFW 1998, vol. 1 appendices) estimated that from 1973-1984, 56% of the winter steelhead returns to the East Fork Lewis were of wild origin. More recent data (LCSCI 1998) estimates that 51% of the spawning winter steelhead in the East Fork are of hatchery origin (see Table 18). WDF (1990) estimated that only 6% of the returning winter steelhead to the North Fork Lewis are wild fish. The East Fork Lewis River winter-run steelhead is of mixed hatchery and native origin. To provide fishing opportunities, approximately 100,000 hatchery-origin smolts are planted annually. The winter-run steelhead stocks in both the East and North Lewis Rivers are identified as depressed by the WDFW (LCSCI 1998)(see Table16).

Historically, winter steelhead were moderately abundant in the Kalama basin and were confined below Kalama Falls Hatchery site (RM 10) in most years. However, in general, the Kalama subbasin has limited natural production potential, especially for steelhead, because the relatively few tributaries are short in length and have high gradients (WDW, 1990). Hatchery fish were sporadically planted into the Kalama system beginning in 1938, with consistent annual plants beginning in 1955. According to the Lower

Columbia Steelhead Conservation Initiative (1998), the Kalama River had the only healthy winter steelhead stock in the lower Columbia ESU in 1997 (see Table 16). WDFW (LCSCI 1998) estimated that 31% of the spawning fish in the Kalama were of hatchery origin (see Table 18).

Table 16 - WRIA 27 Winter Steelhead Stock Status

Stock	Screening Criteria	Proposed 1997 Stock Status	Status (ESA Listing)
Kalama		Healthy	Federal "Threatened"
EF Lewis	Short-Term Severe Decline	Depressed	Federal "Threatened"
NF Lewis	Chronically Low	Depressed	Federal "Threatened"

Adapted from Lower Columbia Steelhead Conservation Initiative, 1998

Table 17 - WRIA 27 Winter Steelhead Stocks

Stock	Stock Origin	Production Type	Data Type	Escapement	Monitoring Period
Kalama	Native	Wild	Trap	Total	1977-1997
EF Lewis	Native	Wild	Redd	Index	1986-1997
NF Lewis (Cedar Creek)	Native	Wild	Redd	Index	1996-1997

Adapted from Lower Columbia Steelhead Conservation Initiative, 1998

Table 18 - WRIA 27 Winter Steelhead Escapement

Stock	Wild Steelhead Escapement Goal	1991-1996 Average Wild Steelhead Escapement	Average % of Wild Escapement Goals	Average % of Hatchery Spawners
NF Lewis	358 (I)	70 (I)	21%	93%
EF Lewis	204 (I)	76 (I)	37%	51%
Kalama	1000	1059	106%	31%

I = index escapement goals and counts
NF Lewis index is based on Cedar Creek data; Ph is for the entire NF Lewis
Adapted from Lower Columbia Steelhead Conservation Initiative, 1998

Chum Salmon (*Oncorhynchus keta)*

Chum salmon migrate to and spawn in the lower reaches of both the mainstem North Fork and East Fork Lewis River. WDF (1951) estimated escapement in 1951 as 3,000 adult spawners. In 1973, WDF estimated the spawning population in both the Lewis and Kalama Basins as only a few hundred fish. According to a 1973 report the most dense observed chum spawning occurred in side channels and upwelling areas in the lower 6 miles of the East Fork Lewis River (WDF, 1973). However, TAG members stated that chum spawning habitat would extend to at least RM 10 today, and that available habitat would extend to Lucia Falls (see Chum Salmon Distribution Map in Appendix A-10). The mainstem Kalama between Lower Kalama Falls (RM 10) and to around Modrow Bridge (RM 2.4) provides all spawning habitat for any chum returning to the Kalama River basin. The 1992 SASSI lists information on only the Grays River, Hardy Creek, and Hamilton Creek stocks for the lower Columbia. Chum salmon populations in the other river systems of the lower Columbia have not been monitored as populations are extremely low (Hawkins 1999 personal comm.). The Columbia River is considered the maximum southerly range of chum salmon.

Very little is known about the life history of chum in the North Fork Lewis River. Smoker et al. (1951) confirmed the presence of chum in the North Fork Lewis River downstream of Merwin dam. Chambers (1957) reported 96 chum spawning just downstream of Merwin dam in mid-November of 1955. Chum were sighted occasionally during 1998 fall Chinook spawning surveys and 4 adult carcasses were observed in Cedar Creek. In addition, about 45 juvenile chum were captured during seining operations related to a smolt residual study in 1998 (R2 Resources). Annually, about 3 or 4 adult chum have also been captured at the Merwin fish trap (R2 Resources 1999).

Lewis River chum salmon are included in the Columbia River ESU and this population was listed by NMFS as "threatened" under the ESA on March 25, 1999. The current abundance of this ESU is estimated to be only 1% of historic levels (R2 Resources 1999).

Bull Trout (*Salvelinus confluentus*)/Dolly Varden (*Salvelinus malma)*

Populations of bull trout/Dolly Varden in the Lewis River have been identified as a distinct stock based on their geographic distribution (WDFW 1998, SASSI). The Lewis River system likely contained both anadromous and fluvial bull trout/Dolly Varden (native char) populations prior to construction of Merwin Dam (WDFW 1998, SASSI). The populations that now exist in Merwin, Yale, and Swift Reservoirs are adfluvial (a life-history type in which spawning and early rearing occurs in streams but most growth occurs in lakes or reservoirs). The populations of bull trout/Dolly Varden in Merwin Reservoir are thought to be fish that were spawned in the upper reservoirs and then spilled over Yale Dam. It is not believed that spawning occurs in Merwin Reservoir (WDFW 1998, SASSI).

Cougar Creek is the only known spawning location for bull trout/Dolly Varden in the Yale Reservoir. Rush and Pine Creeks are the spawning and rearing areas for bull trout/Dolly Varden within Swift Reservoir and the upper Lewis River (see Bull Trout/Dolly Varden Distribution Map: Appendix A-11)

The bull trout/Dolly Varden stock is native and maintained by wild production. Stock status is "Depressed" due to chronically low abundance, and there exists a "moderate risk" of extinction for Lewis River bull trout/Dolly Varden (WDFW 1998, SASSI). Lewis River bull trout/Dolly Varden are part of the Columbia River bull trout distinct population segment (DPS). This DPS is a geographically isolated segment, encompassing the entire Columbia River basin and its tributaries, and the Lewis River supports a sub-population of this DPS. The Columbia River bull trout DPS was listed as "threatened" on June 10, 1998 by the USFWS under the ESA.

Spawner surveys in Cougar Creek since 1988 show an average peak count 22.5 (range seven to 37 fish). In 1991, a spawning population of 46 adults from Swift Reservoir was estimated. The population appears to be rebuilding from 1990 levels when monitoring began, and for the years 1994-1997 the average spawning population in Swift Reservoir tributaries was 240 fish (WDFW 1998, SASSI). This rebuilding coincides with the recovery of such streams as Pine Creek that had been devastated by the eruption of Mt. Saint Helens in 1980.

A 1999 Swift Reservoir Creel Survey found that 7 bull trout were caught and one fish was caught and released in Swift Power Canal, and that three fish were released in Swift Reservoir during 1999 through the month of August (Lesko 1999, personal comm.).

HABITAT LIMITING FACTORS BY SUB-BASIN

Introduction

This Limiting Factors Analysis report discusses the major habitat factors limiting salmon production within subbasins of WRIA 27. For each subbasin, the report examines the condition of a number of habitat variables including; access problems, floodplain connectivity, streambed sediment conditions, in-channel and riparian conditions, water quantity and quality, and biological processes. Habitat conditions were assessed using a combination of existing data from published and unpublished sources, as well as the professional opinion of members of WRIA 27 Technical Advisory Group (TAG). The following summary provides the reader with some background on each of these habitat variables and explain how each variable may be altered by land use activities and/or patterns.

Categories of Habitat Limiting Factors:

<u>Loss of Access to Spawning and Rearing Habitat</u>
This category includes culverts, tide gates, levees, dams, and other artificial structures that restrict access to spawning habitat for adult salmonids or rearing habitat for juveniles. Additional factors considered are low stream flow or temperature conditions that function as barriers during certain times of the year.

Information from three different culvert inventories was reviewed and combined to develop the mapping products for this report (WDFW's SSHEAR database; Clark County Conservation District's recently completed culvert inventory of private and federal lands in WRIA 27; and Clark County Department of Public Work's culvert inventory completed by Clearwater BioStudies, Inc. in 1997). The SSHEAR database and Clark County Conservation District's inventory used similar methodologies for collection and assessment of the passage conditions, while Clearwater BioStudies used different methodologies.

<u>Floodplain Conditions</u>
Floodplains are relatively flat areas adjacent to larger streams and rivers that are periodically inundated during high flows. In a natural state, they allow for the lateral movement of the main channel and provide storage for flood waters, sediment, and large woody debris. Floodplains generally contain numerous sloughs, side channels, and other features that provide important spawning habitat, rearing habitat, and refugia during high flows. This category includes direct loss of aquatic habitat from human activities in floodplains (such as filling) and disconnection of main channels from floodplains with dikes, levees and revetments. Disconnection can also result from channel incision caused by changes in hydrology or sediment inputs.

<u>Streambed Sediment Conditions</u>
Changes in the inputs of fine and coarse sediment to stream channels can have a broad range of effects on salmonid habitat. Increases in coarse sediment can create channel

instability and reduce the frequency and volume of pools, while decreases can limit the availability of spawning gravel. Increases in fine sediment can fill in pools, decrease the survival rate of eggs deposited in the gravel, and lower the production of benthic invertebrates. This category addresses these and other sediment-related habitat impacts caused by human activities throughout a watershed. These impacts include increases in sediment input from landslides, roads, agricultural practices, construction activities, and bank erosion; decreases in gravel availability caused by dams and floodplain constrictions; and changes in sediment transport brought about by altered hydrology and reduction of large woody debris.

Channel Conditions

This category addresses instream habitat characteristics that are not adequately captured by another category, such as bank stability, pools, and large woody debris. Changes in these characteristics are often symptoms of impacts elsewhere in the watershed, which should also be identified in the appropriate category (sediment, riparian, etc.).

Riparian Conditions

Riparian areas include the land adjacent to streams, rivers, and nearshore environments that interacts with the aquatic environment. This category addresses factors that limit the ability of native riparian vegetation to provide shade, nutrients, bank stability, and a source for large woody debris. Human impacts to riparian function include timber harvest, clearing for agriculture or development, construction of roads, dikes, or other structures, and direct access of livestock to stream channels.

Water Quality

Water quality factors addressed by this category include stream temperature, dissolved oxygen, and toxics that directly affect salmonid production. Turbidity is also included, although the sources of sediment problems are addressed in the streambed sediment category. In some cases, fecal coliform problems are identified because they may serve as indicators of other impacts in a watershed, such as direct animal access to streams.

Water Quantity

Changes in flow conditions can have a variety of effects on salmonid habitat. Decreased low flows can reduce the availability of summer rearing habitat and contribute to temperature and access problems, while increased peak flows can scour or fill spawning nests. Other alterations to seasonal hydrology can strand fish or limit the availability of habitat at various life stages. All types of hydrologic changes can alter channel and floodplain complexity. This category addresses changes in flow conditions brought about by water withdrawals, the presence of roads and impervious surfaces, the operation of dams and diversions, alteration of floodplains and wetlands, and a variety of land use practices.

Estuarine and Nearshore Habitat

This category addresses habitat impacts that are unique to estuarine and nearshore environments. Estuarine habitat includes areas in and around the mouths of streams extending throughout the area of tidal influence on fresh water. These areas provide especially important rearing habitat and an opportunity for transition between fresh and salt water. Human impacts to these areas include loss of habitat complexity due to filling, dikes, and channelization; and loss of tidal connectivity caused by tidegates. Nearshore habitat includes intertidal and shallow subtidal salt water areas adjacent to land that provide transportation and rearing habitat for adult and juvenile fish. Important features of these areas include eel grass, kelp beds, cover, large woody debris, and the availability of prey species. Impacts include bulkheads, over-water structures, filling, dredging, and alteration of longshore sediment processes.

The Conservation Commission is only assessing habitat limiting factors within tributaries to the Columbia River, and we will not be addressing habitat issues within the Columbia itself. Therefore, an assessment of estuarine and nearshore habitat is not included in this report.

Lake Habitat

Lakes can provide important spawning and rearing for salmonids. This category includes human impacts that are unique to lake environments, such as the construction of docks and piers, increases in aquatic vegetation, and the application of herbicides to control plant growth.

The only significant lake habitat within WRIA 27 is the reservoirs created by dams on the North Fork of the Lewis River. These reservoirs are now inaccessible to anadromous fish. Passage and potential habitat issues above the dams will be addressed in a number of studies planned as part of the relicensing efforts for the dams on the North Fork. Planned studies should provide significantly more data on habitat conditions and watershed processes within the reservoirs and upper river than is available today. Therefore, lake habitat will also not be addressed in this report.

Biological Processes

This category addresses impacts to fish brought about by the introduction of exotic plants and animals and also from the loss of ocean-derived nutrients caused by a reduction in the amount of available salmon carcasses.

WRIA 27 was divided into four sub-basins for discussion of the habitat limiting factors; the Kalama River basin, the East Fork Lewis River basin, the lower (North Fork) Lewis River basin below Merwin Dam, and the upper (North Fork) Lewis River above Merwin Dam (see Historic Anadromous Distribution with Passage Barriers Map: Appendix A-3 for basin boundaries).

Habitat Limiting Factors on the Kalama River

Access

Information on passage problems that involved culverts and other artificial barriers was gathered from three databases for WRIA 27 (WDFW's SSHEAR database, Clark County Conservation District's recent culvert inventories, and Clark County Department of Public Works' 1996 culvert inventories by Clearwater BioStudies, Inc.). Culverts were either rated as passable or impassable; however, some "impassable culverts" may be passable by certain species and/or at different flow stages. Only culverts that potentially block anadromous habitat for steelhead, coho, or chinook were mapped (see Historic Anadromous distribution with Passage arriers Map: Appendix A-3). Additional assessments of these culverts should be completed before projects are funded for removal or repair. Identification of passage problems associated with potential thermal barriers and/or low-flow barriers, and small dams and other obstructions ("Other Passage Barriers") came from either published data or from personal experience of TAG members.

TAG members noted that channel alterations that have occurred within in the lower Kalama River, combined with excessive sediments from upstream sources, have increased the extent of the bar at the mouth of the river. Migrating adults and juveniles must cross this wide shallow bar with little cover where they are exposed to high levels of predation and elevated water temperatures (see Water Quality Impaired Streams Map: Appendix A-12). This bar poses a potentially serious migration barrier, especially to juveniles moving downstream and out of the system. Habitat conditions on this bar need further assessment to determine the extent of the problem encountered by salmonids of all life-history stages.

The Historic Anadromous Distribution with Passage Barriers Map (Appendix A-3) illustrates where the major culvert access problems occur in WRIA 27. The following is a list of known access problems within the Kalama River watershed including:

- The lower Kalama River Falls has a 3.4 meter drop that has a fish ladder. Only wild steelhead and excess spring chinook are passed above the falls.
- The Lower Kalama River Hatchery presents a partial barrier to migration up Hatchery (Fallert) Creek during low flows.
- A culvert on an Unnamed tributary to Wildhorse Creek, under the 6242 Road is considered a passage barrier.
- A culvert on Wildhorse Creek under the 6240 Road is considered a passage barrier.
- A culvert on Bear Creek (tributary to Gobar Creek) under the 6317 Road is considered a passage barrier and is in need of repair or replacement.
- A log-jam at the mouth of Jacks Creek may be blocking passage.
- Large gravel deposits at the mouths of Langdon Creek, North Fork Kalama, Jacks Creek and Wold Creek create conditions where the flow may become subterranean during low flows. These gravel deposits are likely related to upstream land use

activities, such as, logging and road construction that have removed riparian vegetation and increased peak flows and erosion.

- Just upstream from the Kalama, two small tributaries to the Columbia, Schoolhouse Creek and Bybee Creek, also have culverts that are considered passage barriers (see Historic Anadromous Distribution with Passage Barriers Map: Appendix A-3).

One of the more significant passage problems on tributaries within the Kalama system will be addressed by the construction a bridge across Wildhorse Creek during summer of 2000 opening approximately 11 miles of steelhead habitat.

<u>Floodplain Connectivity</u>
Almost the entire floodplain of the lower Kalama River has been disconnected from the river by the construction of dikes and levees (see Mass Wasting and Stream-Floodplain Connections Map: Appendix A-4). The construction of Interstate-5 first cut off the lower floodplain, and then development on Port of Kalama property completed the channelization of the river. With its steep canyons and tributaries the Kalama River has always had minimal floodplain habitat. Development along the lower river further exacerbates this natural limiting factor.

<u>Bank Stability</u>
Other than a few isolated areas, TAG members rated overall bank stability of the lower Kalama mainstem as "good." The main problem areas identified along the lower river were concentrated along the south bank both upstream and downstream from Spencer Creek (RM 2.2) (see Mass Wasting and Stream-Floodplain Connections Map: Appendix A-4). However, sections around Spencer Creek and other areas along this section of the south bank of the lower river contain naturally unstable soils and it is possible that this is an entirely natural process that has little to do with surrounding land uses.

Much of the upper Kalama mainstem is incised in bedrock and naturally stable. However, the Watershed Recovery Inventory Project (WDFW 1997) identified mass wasting problems along many of the major tributaries to the Kalama river including Hatchery Creek, Wildhorse Creek, Gobar creek, North Fork Kalama, Lakeview Peak Creek, and Langdon Creek (see Mass Wasting and Stream-Floodplain Connections Map: Appendix A-4).

A major slide on the North Fork Kalama that dates from the late 1970s appears to have stabilized. A very large mass soil movement is occurring in the headwaters of the Lakeview Peak Creek. Because of its size, TAG members felt that there was little anyone could do but wait for the movement to stabilize.

<u>Large Woody Debris (LWD)</u>
There is a general lack of LWD throughout the Kalama Basin (WDFW 1998, vol.1 appendices). Some larger pieces can be found in the main channel, and many of these are redistributed every year during high flows. From Jacks Creek (RM 24.6) to the upper falls (RM 35), TAG members felt that there was a fair amount of LWD in the mainstem,

but that it was tied up in log jams and not distributed so that it could significantly enhance habitat throughout the basin. The removal of LWD for firewood is a common occurrence in the lower river, further reducing LWD abundance. Almost all the historically productive tributaries to the Kalama now have low LWD abundance.

The potential for future recruitment of LWD is also poor almost throughout the Kalama River basin. Over 88% of the riparian habitat that was analyzed using aerial photos was rated as "poor" (Lewis County GIS) and contained mainly deciduous species (WDFW 1998, vol.1 appendices). It will be many years before these degraded riparian areas will provide adequate supplies of LWD to the streams. Under the Forest and Fish Report agreements (authors included Tribal, State, timber industry, federal and local government caucuses), future management of riparian zones for non-federal forest lands in the State of Washington should begin to protect riparian zones from additional logging impacts and eventually help provide a limited supply of LWD.

<u>Pools</u>

In general, pool ratios and quality does not appear to be a major limiting factor within the Kalama Basin. According to TAG members, the lower mainstem Kalama has good quality, deep pools and good pool to riffle ratios. Habitat surveys conducted on the Middle Kalama WAU (RM 13 to RM 32) also found adequate pool habitat. However, the tributaries vary from having good pool ratios to very poor pools, which may tend to crowd the majority of the rearing juveniles into areas with adequate pool habitat (WDFW 1998, vol. 1 Appendices).

<u>Side Channels</u>

The channel of lower Kalama River has been largely channelized, with few off-channel areas for juvenile rearing over-wintering. Very few off-channel areas were noted during 1994 surveys of the Middle Kalama WAU (RM 13 to RM 32) (WDFW 1998, vol. 1). With the lack of LWD in most stream channels and potential for increased peak flows due to the extensive logging that has occurred within the basin, winter rearing for juveniles may be a major limiting factor for salmonid production within the basin. Many of the tributaries that might normally provide refuge during high flows are also inaccessible due to gradient barriers near their mouths (WDFW 1998, vol. 1 appendices).

<u>Substrate Fines</u>

Field surveys undertaken during the summer of 1994 as part of the Integrated Landscape Management (ILM) project (WDFW 1998, vol. 1 appendices) on the Lewis-Kalama watershed covered most of Arnold, Wildhorse, Gobar, and Bear Creeks, and the mainstem Kalama from Gobar Creek almost to the North Fork Kalama. These surveys found large quantities of fines throughout the surveyed areas of mainstem and tributaries of the Middle Kalama WAU (RM 17 to RM 32). All segments surveyed had deposits of fines within the gravels and in pools and bars, and all prior information gathered referenced fine sediments as a problem in the basin. The quantities of accumulated fine materials noted during the field surveys indicated an ongoing and persistent supply to the system (WDFW 1998, vol. 1 appendices).

As a surrogate measure of fine sediment inputs, road densities greater than 3 miles/square mile with numerous valley bottom roads are considered to fall in the "poor" category (see Salmonid Habitat Rating Standards in Appendix B). It should be recognized that only rarely can roads be built without negative impact on streams (Furniss et al. 1991). Roads modify natural drainage networks and accelerate erosion processes. These changes can alter physical processes in streams, leading to changes in streamflow regimes, sediment transport and storage, channel bank and bed configurations, substrate composition, and the stability of slopes adjacent to streams (Furniss et al. 1991). The sediment contribution per unit area from roads is often much greater than that from all other land management activities combined, including log skidding and yarding (Furniss et al. 1991). Lewis County GIS (1999) measured 1292 miles of road in the 224.5 square miles of Kalama River watershed, revealing a road density of 5.75 miles/square mile. The Middle Kalama WAU (from approximately RM 17 to 32) has approximately 516 miles of roads with a road density of 6.4 miles/square miles (WDFW 1998, vol. 1 appendices). Road densities on Forest Service property in the upper Kalama are also relatively high, with an average value of 4.0 miles/square mile. The upper Kalama is also the most highly fragmented watershed in the Mt. Saint Helens Administrative Unit, with an average of 2.6 road crossings per stream mile (USFS 1996a).

The erosion potential is also generally high for the most widespread soil type (Olympic series) in the Kalama watershed, especially once the vegetative cover has been removed or roads have been constructed (WDW 1990). Many areas within the Kalama basin are also considered naturally unstable (see Mass Wasting and Stream-Floodplain Connections Map: Appendices A-4 from WRIP 1997), and past logging and road construction within the watershed have likely exacerbated this natural instability. The February 1996 flooding triggered at least 39 new slides in the Kalama River basin (USFS 1996a).

The watershed is slowly recovering from past logging impacts. TAG members noted that after a heavy rain the river carries much less sediment than after the period of extensive logging in the 1970s, and that the river clears up quickly as well. The recovery of riparian areas from past logging activities coupled with stabilizing road systems appears to be resulting in improvements in sediment delivery to stream systems. Changes in road construction and maintenance practices have also likely reduced sediment inputs from roads. However, excessive chronic inputs of fine sediments to the river can be expected to continue in areas with such high road densities (Brown and Krygier 1971; Weaver et al. 1987). And, several studies in the western Cascade Range in Oregon showed that mass soil movements associated with roads are 30 to over 300 times greater than in undisturbed forests (Sidel et al. 1985; Furniss et al. 1991).

Data is not available for substrate conditions in the mainstem Kalama below the lower falls. However, TAG members familiar with the river felt that this reach contained patches of fair to good spawning gravels. TAG members also thought that although the floods of 1996 may have triggered a number of new slides within the watershed, they also may have benefited substrate conditions by sorting gravels and scouring fines from spawning beds in the mainstem.

Another problem that was noted by TAG members was that excessive amounts of coarse sediments have collected near the mouths of some tributaries, especially at Langdon Creek and the North Fork Kalama. This process may be the result of mass wasting and increased peak flows associated with earlier logging activities.

Riparian

Approximately 96 percent of the Kalama River Watershed is owned and managed by private timber companies. Most of the watershed was logged in the late 1960s through the early 1980s; current timber harvest is minimal in comparison (WDFW 1998, vol. 1 appendices). A majority of the riparian zones along the tributaries were harvested to the streambanks, and LWD was often removed from the streams as required by law at that time. Early successional deciduous species have proliferated within these harvested riparian areas (WDFW 1998, vol. 1 appendices).

Riparian conditions were assessed along individual stream reaches within WRIA 27 by analysing 1996 aerial photos from Clark County GIS and 1994 aerial photos of Weyerhauser's St. Helens Tree Farm operations. Where riparian vegetation was clearly lacking and/or contained mostly deciduous species, the reach was mapped as "poor" (see Riparian Conditions Map: Appendix A-14). This analysis does not represent a full accounting of all "poor" riparian conditions within the WRIA, just a conservative estimate of where riparian areas were clearly in "poor" condition (see Appendix B for habitat rating standards). Of the 97.25 miles of anadromous habitat within the Kalama River basin, over 85 miles have "poor" riparian conditions (Lewis County GIS 1999). Even if sufficiently wide riparian buffers are protected from future logging under the ongoing Forests and Fish Report agreements, the existing conditions assure that it may be a hundred years or more before many streams reach "good" riparian condition. These same conditions assure that there will be minimal future potential for large wood recruitment in most of the Kalama Basin for at least the next 100 years. Past logging practices in the upper Kalama on forest service lands have also reduced future recruitment of large woody debris (USFS 1996a).

Riparian conditions are slowly improving, and there are sporatic reaches along the mainstem Kalama and some of the tributaries that still contain riparian areas with mature conifers. However, the TAG noted that Wildhorse Creek, North Fork Kalama, Gobar Creek, Lakeview Peak Creek and Arnold Creek, historically the most productive steelhead streams, have particularly "poor" riparian conditions.

Water Quality

Segments of the lower 10 miles of the Kalama River are considered water quality impaired (303 d listed) due to excessive water temperature (see Water Quality Impaired Streams Map: Appendix A-12). Hatchery (Fallert) Creek is also on Washington State Department of Ecology's 303d list due to numerous excursions beyond the water temperature criteria at the inflow to the Lower Kalama Hatchery (WDOE 1999). Water temperatures problems are likely exacerbated in the shallows created by the growing bar at the mouth of the Kalama, possibly presenting a thermal barrier to migrating fish during summer low flows.

Water temperatures may also be a problem in many of the stream segments where the riparian canopy has been removed. However, stream temperatures noted during 1994 summer low flow surveys of the Integrated Landscape Management process were between 55 and 58 degrees F (12.7 to 14.4 degrees C) in all measured segments of the Middle Kalama WAU (WDFW 1998, vol. 1 appendices). Although the Forest Service has limited water temperature monitoring data, it indicates that water temperatures in most stream systems in the upper basin meet or exceed state standards. However, Fossil Creek is an exception, with elevated water temperatures that could impact salmonid growth and disease resistance (14-23 degrees C) (USFS 1996a). There is little data available for water quality parameters for the rest of the system. In general, TAG members felt that water quality had improved since the 1970s and early 1980s when extensive logging and road construction were occurring throughout the basin.

Water Quantity

Similar to water quality, TAG members felt that the hydrograph (low and high flow extremes) has probably improved since the 1970s when extensive logging was occurring. However, road densities as high as 6.4 miles/square mile in the Middle Kalama WAU increase the stream channel network significantly which can increase peak flows (WDFW 1998, vol. 1 appendices). Looking at the potential impacts to hydrology in the upper basin from the number of roads/mile and vegetation removal, the USFS (1996a) found that within 6 of 8 subbasins peak flows could increase over 10%. Higher peak flows can accelerate erosion and sediment loading, and alter channel morphology, all of which can have negative impacts on salmon habitat (Furniss et al. 1991).

In June 1999, Washington Department of Ecology completed a streamflow study for the Kalama River in Water Resources Inventory Area 27 (WRIA 27) to quantify available salmonid habitat at various stream flows. Ecology conducted this study to provide information to determine minimum stream flows in the WRIA as is required by state law. Ecology used the Instream Flow Incremental Methodology (IFIM) for the Kalama River and a description is available in Publication #99-152 available from Ecology (Caldwell et al. 1999). The IFIM estimates available habitat for various salmonid species as percentage of optimal habitat as stream discharge varies. Using the IFIM model, a weighted useable area (WUA) for fish spawning and rearing is calculated using 4 variables, depth, velocity, cover and substrate. The WUA varies by species and life stages as flow changes. Optimal stream flow can then be determined by considering spawning and rearing flow requirements, for various species (see Table 19).

Four transects were established for the study, one transect near river mile 4.2 and one transect at river mile 5.2. Table 19 provides data on the percent of optimum habitat available at various flows in the Kalama River. The results show that median-flows in the Kalama range from approximately 300 cubic feet per second (c.f.s.) in early October to near 700 c.f.s. near the end of October. The flow levels are less than optimal for coho and chinook spawning in October, but flows approach optimal levels for coho spawning in early November and optimal chinook spawning levels by mid-November (Loranger 1999). There is generally plenty of water in the river to support steelhead spawning in the spring. Optimal juvenile rearing habitat occurs at about 600 c.f.s. for chinook salmon and 950 c.f.s. for steelhead (see Table 19). Median flow levels in the Kalama are below 600 c.f.s. from mid-June to mid-October, consequently juvenile rearing habitat is less than optimal during this period.

There is also concern about low flow problems in some of the tributaries. TAG members identified Langdon Creek as an area of particular concern because the flow becomes subsurface at times in the coarse sediments that have accumulated near the mouth. Juveniles rearing in the stream may become stranded in warm remnant pools as the flow becomes intermittent. Similar accumulations of coarse sediments occur at the mouths of the North Fork Kalama, Jacks and Wold Creeks (WDFW 1998 vol. 1 appendices). Water withdrawals are not considered a major concern within the Kalama basin today; however, extensive development is occurring within the lower basin and water withdrawals could become a problem in the near future.

Biological Processes

The Conservation Commission is using the number of stocks meeting escapement goals as a surrogate measurement of nutrient levels within stream systems. Actual data on nutrient levels and cycling would provide a much more accurate picture of the conditions within the watershed.

Populations of Kalama River fall and spring chinook and winter steelhead are all considered “healthy” and generally meeting escapement goals (WDF/WDW 1993; WDFW 1998). The carcasses from these populations are providing nutrients to the lower areas of the river, downstream of the lower falls. However, populations of summer steelhead and coho salmon are considered depressed and not meeting escapement goals for the Kalama River. Returns of chum salmon are almost nonexistent.

The river above the falls is likely the area where nutrient enhancement might provide the greatest benefits. The only fish released above the falls are steelhead and occasionally spring chinook when there are excesses at the hatchery. A nutrient enhancement program is underway for the Kalama River, with the planting of 1,904 fish in 1997 and 3,444 fish in 1998 (Hale 1999, personal comm.). Additional studies are needed to truly define the number of fish that could be supported by the amount of available habitat in the Kalama, and then to determine the level of nutrient enhancement required to maintain that level of productivity.

Table 19 - Percent of Optimum Habitat (WUA) at varied flows on the Kalama River

Flow in cfs	**Steelhead Spawning** %Optimum	**Steelhead Juvenile** %Optimum	**Chinook Spawning** %Optimum	**Chinook Juvenile** %Optimum	**Coho Spawning** %Optimum
2050	52%	91%	59%	75%	56%
1900	55%	90%	63%	75%	57%
1700	61%	92%	69%	76%	63%
1500	70%	94%	81%	83%	73%
1400	78%	95%	86%	89%	79%
1300	84%	97%	91%	91%	84%
1200	90%	97%	95%	93%	89%
1100	94%	99%	99%	93%	94%
1025	96%	100%	100%	92%	96%
1075	95%	99%	**100%**	92%	95%
1050	95%	**100%**	**100%**	92%	96%
1000	98%	**100%**	99%	92%	97%
975	**100%**	**100%**	99%	93%	99%
950	**100%**	**100%**	98%	93%	99%
925	**100%**	**100%**	98%	94%	100%
900	**100%**	**100%**	97%	94%	**100%**
875	**100%**	**100%**	96%	94%	**100%**
850	99%	**100%**	94%	95%	99%
825	98%	99%	93%	95%	99%
800	97%	98%	91%	96%	**100%**
750	95%	97%	87%	98%	99%
700	91%	95%	85%	99%	98%
650	87%	92%	81%	99%	97%
625	85%	91%	80%	**100%**	96%
600	83%	90%	78%	**100%**	96%
575	79%	88%	77%	**100%**	95%
550	75%	87%	75%	99%	94%
500	70%	83%	70%	97%	90%
300	49%	64%	45%	85%	69%
100	33%	36%	27%	60%	49%

(from Loranger 1999)

Habitat Limiting Factors on the Lower Lewis River (to Merwin Dam)

<u>Access</u>
The system of dams on the Lewis River is the most significant factor limiting salmon habitat on the Lewis River system. Construction of Merwin Dam blocked access to approximately 80 percent of the available habitat for steelhead in the North Fork Lewis (WDFW 1998, vol. 1 appendices). Without both upstream and downstream passage through the dams, restoration of self-sustaining runs of summer steelhead and spring chinook populations is improbable (Rawding 1999, personal comm.).

The Historic Anadromous Distribution with Passage Barriers Map (Appendix A-3) illustrates where the major access problems occur in WRIA 27. The following is a list of known access problems within the lower Lewis River watershed below Merwin Dam including:

- Robinson Creek (RM 9.1) has a partial barrier at low flows near the mouth. Upstream 1.5 miles of the culvert is an impassable falls.
- Ross Creek (RM 10.1) has a possible obstruction near the mouth that needs assessment.
- Johnson Creek (RM 15.2) has a culvert under the Lewis River Highway that is a possible partial barrier. Spawning has only been observed in areas below the obstruction.
- Colvin Creek (RM 16.2) has a dam that at one time provided water to the hatchery. The water intake is no longer in use and the dam forms a complete passage barrier for all species.
- Cedar Creek (RM 15.6) has a potential velocity barrier at NE Amboy Rd., as identified by Clark County culvert survey 1997.
- Pup Creek (Tributary to Cedar Creek RM 4.4) has an impassable dam on a small tributary.
- Beaver Creek (RM 5.0) has potential passage problems through three culverts; under Cedar Creek Rd where baffles are possibly broken; at NE 414th St., and at Munch Rd. where culverts are undersized with significant drops at the outfalls.
- John Creek (RM 7.8) has possible blocking culvert under NE Cedar Creek Rd.
- Brush Creek (RM 9.3) has a culvert under Cedar Creek Rd. that is a probable high flow barrier.
- Unnamed Creek (RM 10.3) has two lower culverts that need repair or replacement to allow access to approximately 1.5 miles of coho and steelhead habitat.

<u>Floodplain Connectivity</u>
The lower 7 miles of the floodplain of the Lewis River is almost entirely disconnected from the river due to extensive diking (see Mass Wasting and Stream-Floodplain Connections Map: Appendix A-4). Dikes protect the farmland to the north of the river in the Woodland Bottoms, as well as the town of Woodland. The TAG estimated that

greater than 50% of the historic floodplain has been disconnected from the river, significantly reducing juvenile rearing and overwintering habitat within the lower reaches of the river.

Above RM 7 to RM 15, many areas of the river have been rip-rapped to protect residential and road development. However, there are few dikes and there is connection to some off-channel habitats and associated wetlands around Eagle Island (RM 9.9 to RM 11.8) and around Happa Boat Launch (RM 14). Above RM 15 the river is confined within a canyon. Floodplain restrictions on other tributaries to the North Fork Lewis were not considered to be a limiting factor.

Bank Stability

Bank stability along most of the lower 7 miles was considered “good,” since the river has been mostly channelized and rip-rapped to protect the dikes and developed lands. Above Woodland (RM 7 to RM 15) bank stability becomes a problem within certain reaches (see Mass Wasting and Stream-Floodplain Connections Map: Appendix A-4). The off-channel areas within this reach of the river provide critical rearing habitat for juvenile fall chinook salmon. Bank erosion from areas along the golf course (RM 12) and across from Eagle Island can and likely does negatively impact juveniles using these important rearing habitats. Above RM 15 the channel is contained within steep canyons composed primarily of bedrock. Bank stability is very good within this reach.

A large slide recently occurred approximately 2 miles upstream of the hatchery intake on Colvin Creek. The slide occurred below a large clear-cut on State Lands administered by the DNR. Water quality has been affected by sediment pulses from this slide to the point that hatchery staff decided to move one-million eggs to other hatcheries. Geologic surveys are underway to attempt to determine the exact cause of the slide. Initial investigations of the slide point to logging on unstable and steep slopes as the cause.

Bank stability was considered “good” along the lower sections of Cedar Creek (to Pup Creek RM 4.4) where the stream flows through steep canyons with intact riparian buffers. Between Pup Creek (RM 4.4) and Chelatchie Creek (RM 11.2) overall bank stability along Cedar Creek was considered “poor.” Bank instability problems are especially acute between Brush Creek (RM 9.3) to one-half mile short of Amboy, where past and present land uses have altered the riparian zones and destabilized the stream banks. Above Amboy to the headwaters, the TAG rated Cedar Creek’s overall bank stability as “fair.”

Overall bank stability in the South Fork Chelatchie Creek was also considered “fair.” Significant problems were noted with bank stability just downstream of the Highway 503 bridge where cattle grazing has eliminated riparian vegetation and destabilized streambanks. Overall bank stability within the North Fork Chelatchie was also considered “fair.”

LWD

The large woody debris (LWD) concentrations within the entire mainstem Lewis and almost every tributary were considered “poor” by TAG members. Colvin Creek was the only basin in the system where LWD concentrations were considered fair and that was only in the lower reach below the dam. A combination of extensive logging within riparian areas, past efforts to clear the streams of LWD, and the lack of LWD recruitment from areas above the dams has left stream systems deficient in LWD. The USFS (1996a) considers potential recruitment for LWD low where subbasins have greater than 30% of their riparian areas logged. Considering that over 50 percent of the riparian habitat within the lower Lewis River system below the dams was rated as “poor,” the potential for LWD recruitment is likely to remain low well into the future (Lewis County GIS 1999) (see Riparian Conditions Map: Appendix A-14).

In general, LWD concentrations on Cedar Creek were considered “poor.” Data was not available for LWD on Cedar Creek between the mouth and Pup Creek (RM 4.4). On the rest of the Cedar Creek system, including the major tributaries, TAG members rated LWD concentrations as “poor.” Considering the overall poor condition of riparian habitat on Cedar Creek and its’ tributaries the potential for future recruitment of LWD would also be considered poor (Lewis County GIS 1999).

Pools

The lower mainstem and North Fork Lewis River to RM 11 are a tidally influenced backwater of the Columbia River. The lower 7 miles to the City of Woodland is essentially a continuous pool when the Columbia River is high. Above Woodland to RM 15 the percentage of the river that contains pools was considered “good;” however, TAG members stated that the area contains more glide habitat than true pool habitat (true pool habitat includes deep pools with a wide range of water velocities). From RM 15 to Merwin Dam (RM 20) the river is entrenched in bedrock, and the pool percentage and pools per mile is largely controlled by the geology. Pool habitat in this portion of the river is likely similar to historical conditions.

Pool habitat within the lower reaches of Cedar Creek (to RM 4.4) is also largely controlled by bedrock. Between RM 4.4 and RM 11.2 the number of pools per mile was considered “fair;” however, this area also contains more glide than true pool habitat. From RM 11.2 to the headwaters of Cedar Creek, TAG members rated pool conditions as “poor.” This reach is generally high gradient and lacks the concentrations of LWD that could help create good pool habitat. Pool habitat within the North Fork Chelatchie Creek falls in the fair category.

There was a general lack of published data and personal knowledge of pool conditions within most of the tributaries to the North Fork Lewis River.

Side Channels

Side- and off-channel habitats are very limited in the lower Lewis River. Most of the lower 7 miles of the river has been diked and channelized to prevent flooding of urban and agricultural areas (see Mass Wasting and Stream-Floodplain Connections Map: Appendix A-4). Between the City of Woodland (RM 7) and Johnson Creek (RM 15) there are concentrated areas with good quality side channels. For example, good quality side channel habitat around Eagle Island provides critical rearing habitat for juvenile Lewis River fall chinook. Between RM 15 and Merwin Dam the river is contained within a steep bedrock canyon and side-channel habitat has probably not changed from historic conditions.

Substrate Fines

The lower 11 miles of the North Fork mainstem is a tidally influenced backwater of the Columbia where finer substrates are predominant. Detailed information on substrate condition within the North Fork below the major spawning areas from RM 15 is lacking.

Stillwater Sciences (1998) undertook a pilot assessment of gravel quality for spawning fall chinook salmon in the Lewis River downstream of Merwin Reservoir (the two sample sites were located 0.6 and 0.3 miles downstream of Merwin Dam). The purpose of this pilot project was to provide a preliminary assessment of spawning gravel composition and permeability in the river and to identify whether substrate might be limiting to chinook salmon production. Conclusions from the pilot project include:

- That fine sediment does not appear to have accumulated in spawning gravel downstream of Merwin Reservoir.
- In the area of high spawning usage, fines <1mm comprised less than 1.5% of the substrate to a depth of 1.4 feet.
- In an area of lower spawning usage (chosen for its high sand content relative to typical conditions for the area), fines <1mm comprised only 8% of the substrate to a depth of 1.6 feet.

Using the Conservation Commission’s standards for substrate fines (<11 % of fines <0.85mm is considered good - see Appendices B), the quality of spawning gravel below Merwin reservoir would be considered very good.

PacifiCorp will be conducting a sediment budget study, and a Stream Gravel and LWD Study as part of the relicensing process for the Lewis River dams that should provide additional data on sediment supplies into downstream spawning areas (PacifiCorp/Cowlitz PUD 1999).

As a surrogate measure of fine sediment inputs, road densities greater than 3 miles/square mile with numerous valley bottom roads are considered to fall in the “poor category” (see Salmonid Habitat Rating Standards in Appendix B). Lewis County GIS (1999) measured 581 miles of road in the 117.19 square miles of lower Lewis River watershed (below Merwin Dam), creating a road density of 4.96 miles/square mile. This suggests that excessive sediments are likely reaching stream systems within the watershed. The main spawning areas for fall chinook in the mainstem above RM 15 are not affected by this high road density because the dam captures most fine sediments. However, such high road densities would likely negatively impact tributaries to the Lewis.

Unlike the mainstem Lewis River, TAG members considered substrate conditions within the middle reaches (RM 4.4 to RM 11.2) of Cedar Creek as “poor.” Fine sediments are embedded within the spawning substrates throughout this stretch of Cedar Creek. Between Chelatchie Creek (RM 11.2) and the headwaters there are areas where the substrates are also largely embedded with fines, especially just above Amboy. TAG members also noted extensive problems with substrate fines within the South Fork Chelatchie Creek. There are a number of areas where livestock have access to Cedar Creek and its tributaries, reducing riparian vegetation, increasing bank instability, and adding excessive fine sediment to the streams. Residential development along stream corridors is also likely contributing fine sediment to the system.

<u>Riparian Conditions</u>

Riparian conditions were assessed along individual stream reaches within WRIA 27 by analysing1996 aerial photos from Clark County GIS and 1994 aerial photos of Weyerhauser’s St. Helens Tree Farm operations. Where riparian vegetation was clearly lacking and/or contained mostly deciduous species, the reach was mapped as “poor.” The analysis conservatively determined only where riparian areas were clearly in “poor” condition (see Appendix B for habitat standards). While most of the riparian conditions along North Fork tributaries would fall in the “poor” category (< 75 feet or dominated by hardwoods), many riparian areas are now recovering from past land uses (see Riparian Conditions Map: Appendix A-14). Members of the TAG felt that while many areas with mainly deciduous canopy cover would be rated as “poor” using the Conservation Commissions’ rating standards, deciduous canopies are still providing shade and other functions of an intact riparian zone.

Along the lower reaches of the North Fork Lewis, riparian areas have been diked, and residential and agricultural land uses have eliminated most of the vegetation. Eagle Island (RM 9.9 to RM 11.7) has large areas with minimal riparian vegetation, where the invasive species Scot’s broom has proliferated. Above RM 15 on the North Fork the riparian conditions improve significantly, especially along the south side of the river.

Riparian conditions were generally rated as “poor” along Robinson, Johnson, and Ross Creeks. The lower section of Cedar Creek to Pup Creek (RM 4.4) has generally good riparian cover with a wide buffer. Between Pup and Chelatchie Creeks riparian conditions are generally “poor.” Cattle and horse grazing and residential development has removed or reduced the riparian vegetation along much of this section of Cedar Creek. Between the town of Amboy and Yacolt, the canopy cover along Cedar Creek is generally fair. However, the canopy cover and riparian zones along the upper reaches of the creek have been heavily impacted by commercial logging operations.

Riparian conditions along the South Fork Chelatchie Creek are generally “poor” (see Appendix A-14). However, this low gradient stream has numerous natural open areas of wetlands and prairies that historically may not have supported extensive coniferous forests. While there is some deciduous canopy cover along the lower reaches, most of the North Fork Chelatchie Creek riparian zone is in "poor" condition.

Water Quality

Extensive water quality data is available on the mainstem North Fork Lewis River, and to a lesser degree on Cedar Creek. Water quality in the mainstem of the North Fork is generally good. Discharge water temperatures from Merwin Dam are extremely stable (with an average daily fluctuation of less than 0.3 degrees C), reflecting the operation of this project as a flow regulating facility (PacifiCorp 1999). Other water quality parameters arewithin state standards.

Cedar Creek however, has some large problems with high water temperatures during the summer months (PacifCorp 1999). Both at Amboy and at the mouth, water temperatures often exceed 16 degrees C during July and August, and sometimes reach near lethal temperatures for salmonids (23-25 degrees C) (see Figures 7 and 8). Water temperatures in the North Fork Chelatchie Creek are generally "good," even during the summer months. TAG members attribute the cool, clear water flowing from the North Fork Chelatchie basin to wetland complexes in the headwaters of the creek.

Figure 3 - Water temperatures in Cedar Creek at Amboy

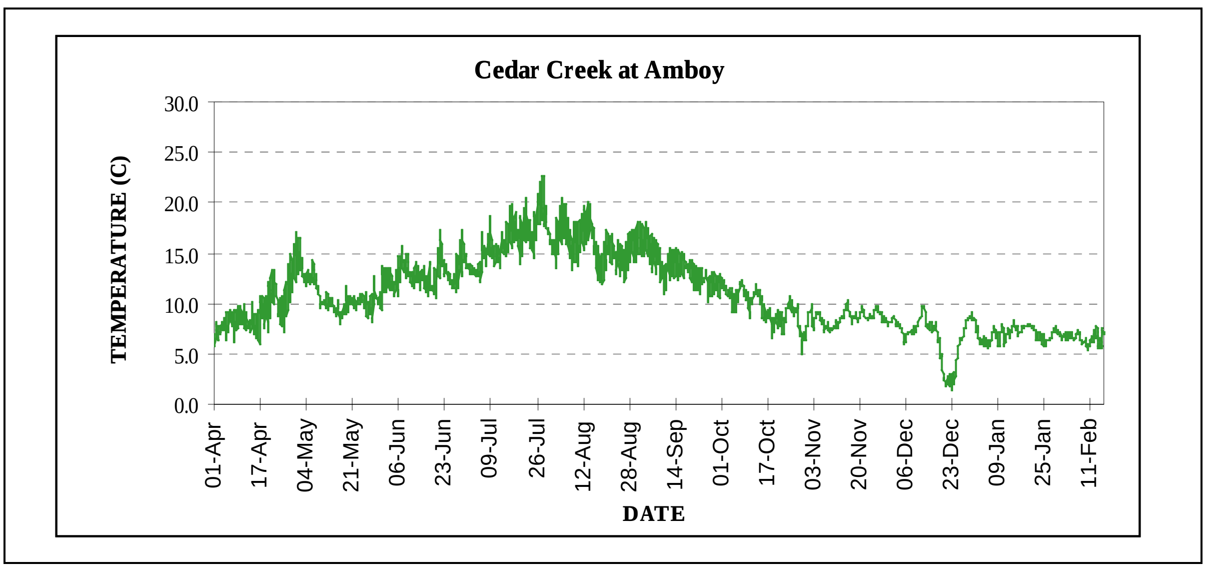
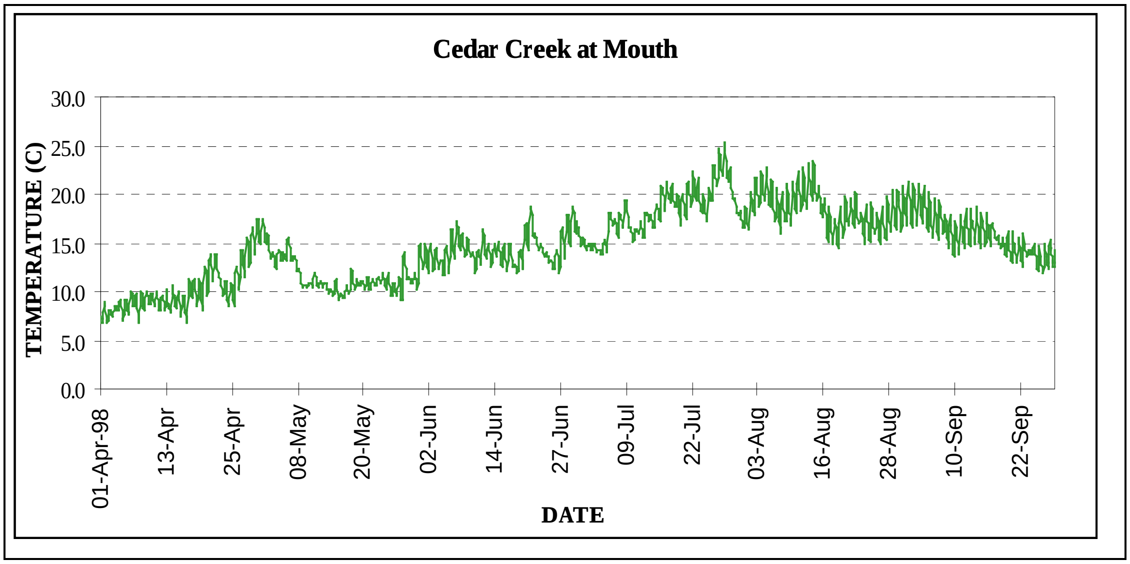


Figure 4 - Water temperatures in Cedar Creek at the Mouth



PacifiCorp 1999

Various land use activities may be affecting water temperature within the Cedar Creek basin including, agriculture and grazing, water withdrawals, surface runoff, and riparian impacts from residential development and forestry operations, and the construction of illegal dams and diversions on tributaries to Cedar Creek.

Water quality information is generally lacking for other tributaries within the lower North Fork Lewis River basin.

<u>Water Quantity</u>

Management of the flow in the North Fork Lewis is largely controlled through the Merwin Project licensing agreement with the operator of the dam, PacifiCorp. Since 1985, PacifiCorp and the Washington Departments of Fisheries (WDF) and of Wildlife (WDW) have studied the relationship between spring flows and fall chinook rearing habitat on the lower Lewis River and evaluated the need to modify spring flow provisions in Article 49 of the licensing agreement. In 1995, Article 49 was amended to provide for increased minimum flows of 2700 cfs in April, May, and June (WDFW Vol. 1 Appendices, 1998). The need for additional modifications of flow regimes and ramping rates to protect other ESA listed species will be assessed as part of the ongoing relicensing studies for the dams (Lesko personal comm. 1999).

Ecology used the "Toe Width" method for the 13 tributary streams in the Lewis River watershed to estimate available habitat for various salmonid species at various flows (description of this method is available in Publication #99-151 from Ecology - Caldwell et al. 1999).

The toe width is the distance from the toe of one stream bank to the toe of the other stream bank across the channel. When used in a power equation, the toe width can be used to derive optimal flows for spawning and rearing of salmonids. The Toe Width method was used in calculating optimum spawning and juvenile rearing habitat based upon stream flow in tributary streams (see Table 20). Stream gauge data with a period of record of at least 22 years is available for three tributaries of the North Fork Lewis River: Canyon Creek (near Amboy), Cedar Creek (near Ariel), and Speelyai Creek (near Cougar). In addition spot flow measurements were taken by the Department of Ecology in 1998 (see Table 21).

Table 20 - Toe Width Flows for North Fork Lewis River Tributaries

Stream Name	**Tributary to**	**Average Toe Width (in feet)**	**Toe-Width Flow for Fish Spawning and Rearing (in cfs)**					
			Chinook Spawning	Coho Spawning	Chum Spawning	Steelhead Spawning	Steelhead Rearing	Salmon Rearing
Cedar Creek (nr Lewis River Hatchery)	Lewis River	53.3	188.2	100.5	188.2	156.1	46.4	42.6
Canyon Creek (@ NE Healy Rd)	Lewis River	68.3	256.0	139.1	256.0	208.1	66.0	60.9
Speelyai Creek (@ HWY 503)	Merwin Lake to Lewis River	49.7	172.6	91.7	172.6	143.9	42.0	38.5
Cougar Creek (@ HWY 503)	Yale Lake to Lewis River	43.5	146.3	77.1	146.3	123.3	34.8	31.8

Table 21 - Spot Flow Measurements in North Fork Lewis River Tributaries

WRIA 27 Measured Flows (in cfs)			
NF Lewis River Tributaries	**9/10/98**	**10/9/98**	**11/9/98**
Cedar Creek (near Lewis River Hatchery)	11.3	74.3	94.4
Canyon Creek (@ NE Healy Rd)	34.7	129.4	110.8
Speelyai Creek (@ HWY 503)	2.6	79.8	66.9
Cougar Creek (@ HWY 503)		76.7	66.8

Adapted from Loranger 1999

The results of the study show that in Cedar Creek flows approach optimal spawning levels for all fall spawners by the end of November. Steelhead spawning becomes flow limited in June, and juvenile rearing habitat is very limited in June through October. Speelyai Creek has severe juvenile rearing limitations because of low flow in the June through November period. Flow conditions are near optimal for summer steelhead spawning through May and coho spawning in November. Other fall spawners are habitat limited because of low flows during the fall. Stream gauge data is not available for Cougar Creek, however spot flow data indicate that coho spawning flows were near optimal as were juvenile rearing conditions for all salmonids during the late summer and fall of 1998 (Loranger 1999).

Biological Processes

The Conservation Commission is using the number of stocks meeting escapement goals as a surrogate measurement of nutrient levels within stream systems. Three species are not meeting escapement goals in the North Fork Lewis River; winter and summer steelhead, and coho salmon. Very few chum salmon return to the watershed; however, at one time the estimated escapement from the Lewis River was 3,000 fish (WDF 1951). These low escapement numbers mean a loss of ocean-derived nutrients from salmon carcasses that could be a limiting factor within the basin. A nutrient enhancement program is underway on the North and East Fork Lewis River systems. In 1997, WDFW and volunteer groups planted 1407 fish carcasses in tributaries to the North and East Forks of the Lewis River. In 1998, they planted 4,659 carcasses (Hale 1999, personal comm.)

Habitat Limiting Factors on the Upper Lewis River (above Merwin Dam)

PacifiCorp and Cowlitz County PUD are in the process of relicensing the hydroelectric projects on the Lewis River (Merwin, Yale, and Swift #1 and #2). As part of this process they will be conducting a number of studies on watershed processes, water quality and quantity, and aquatic resources. Once completed, these studies should add substantially to the database on habitat conditions within the Lewis River. This Limiting Factors Analysis report will include only a limited amount of detail on habitat above the dams (RM 20 to the headwaters), since passage for anadromous species is now blocked and since relicensing studies will provide much more detailed information in the near future. Instead, this report will focus on steams with habitat for bull trout/Dolly Varden in the upper watershed.

Access

Construction of Merwin Dam blocked access to approximately 80 percent of the available habitat for steelhead in the Lewis River (WDFW 1998, vol. 1 appendices). The Historic Anadromous Distribution with Passage Barriers Map (Appendix A-3) shows the potentially available habitat for anadromous salmonids above the dams within the upper Lewis River and its tributaries. Slopes in the upper portions of the basin are generally steep, resulting from the incision of numerous streams into the geologically young landscape (EA Engineering 1999). Therefore, most of the tributaries have natural barrier falls or are too precipitous for spawning (Chamber 1957). The reservoirs have further limited available habitat by inundating the lower portions of many of these streams. Over 25 miles of stream habitat was converted to lake habitat as the reservoirs were filled (USFS 1995c).

Floodplain Connectivity

The upper Lewis River flows through areas with steep slopes and minimal amounts of floodplain habitat. Any floodplain habitat that may have existed along the mainstem North Fork or within the lower reaches of the tributaries has likely been inundated by the reservoirs.

Bank Stability

Surface erosion is a concern primarily in the northern half of the upper watershed due to tephra deposits from past eruptions of Mt. St. Helens (USFS 1995b). The ash and pumice soils from these eruptions are highly erodible and easily transported. Specific information on bank stability was not available; however, the number of acres of unstable and potentially unstable land was assessed as part of the Lower Lewis River Watershed Analysis (covering the upper portions of Yale Lake to above Swift Reservoir) (USFS 1995b). Over 11 % of the Pine Creek subbasin is considered potentially unstable with approximately 621 (or 0.05%) acres that are known to be unstable. Over 40% of both the upper and lower subbasins of Cougar Creek contain potentially unstable ground (USFS 1995b).

The "Middle Lewis River Watershed Analysis" (RM 59.5 to RM 74.7) area has numerous mass-wasting features (landslides and debris flows) that have impacted streams within the basin (USFS 1995c). All of the subbasins bordering the Lewis River contain areas of concern from mass-wasting and should be examined prior to initiating any ground disturbing activities (USFS 1995c).

Large Woody Debris (LWD)

Staff from the Gifford Pinchot National Forest surveyed LWD quantities within stream systems of the upper Lewis River basin and categorized the conditions according to the Columbia River Basin Policy Implementation Guide (PIG). Rush Creek has what the Forest Service characterizes as "good" LWD quantities (>80 pieces of LWD per mile) (USFS 1995c). LWD concentrations in Pine Creek were considered "poor" at < 40 pieces per mile. Pine Creek also has low recruitment potential, as a significant amount of the watershed has been either logged or affected by the eruption of Mt. St. Helens (USFS 1995b). Cougar creek was not surveyed since most of the system is outside of the Forest Service boundaries on private property.

Pools

The Forest Service also surveyed pool habitat within tributaries to the upper Lewis River. The number of pools per mile within Rush Creek was considered "good," using the PIG standards that the Forest Service uses in their watershed analysis. Pine Creek also had a "good" number of pools per mile, especially in the lower reaches (USFS 1995b and 1995c). Pools within Cougar Creek were not assessed.

Side Channels
Side channel habitat is likely limited in the incised stream systems that dissect the steep, volcanic terrain of the upper Lewis River basin. However, data on side channel habitat within the upper Lewis was unavailable.

Substrate Fines
Data on substrate fines within the upper Lewis River basin is limited. The Conservation Commission and NMFS use road densities as a surrogate measure of chronic sediment input into stream systems (see Appendix A). Road densities greater than 3.0 miles/square mile of area are considered to contribute excessive fine sediments and represent a "poor" substrate fines condition. The average road density within the "Lower Lewis River Watershed Analysis" area, between the upper portions of Yale reservoir (RM 42.4) to just above Pine Creek (RM 59.5) is 3.41 miles/square mile (USFS 1995b). Lower Pine Creek is one of the worst subbasins within the analysis area with a very high road density of 6.44 miles/square mile. The lower Pine Creek basin also has a high number of stream crossings per mile according to Forest Service standards, which fragments instream habitat (USFS 1995b). Habitat within Pine Creek was also severely impacted by both past timber harvests and mudflows that occurred due to the eruption of Mt. St. Helens (USFS 1995b), contributing additional inputs of fine sediment to the stream.

Road densities within the Cougar Creek watershed are lower than the densities within Pine Creek. The upper Cougar Creek subbasin has the higher road density with 3.51 miles/square mile, while the lower Cougar Creek subbasin has only 1.82 miles/square mile (USFS 1995b).

The road density for the entire "Middle Lewis River Watershed," from above Pine Creek (RM 59.5) to just above Alec Creek (RM 74.7), is 2.53 miles/square mile, representing sediment inputs that would fall in the "fair" category. The road density in the lower Rush Creek subbasin is 3.7 miles/square mile, which represents potentially excessive fine sediment inputs to the system (see Appendix B). However, the road density in the upper Rush Creek subbasin is only 0.7 miles/square mile. Flood events in the 1970's sent large pulses of sediment into Rush Creek increasing the average channel width 38 percent (USFS 1995c). The stream has adjusted to these sediment pulses over time by channel narrowing and/or downcutting.

Riparian Conditions
Since about 1940, approximately 31% of National Forest lands within the "Lower Lewis River Watershed Analysis area" have been harvested (1995b). A much higher proportion of the non-National Forest lands has also been harvested. Pine Creek was divided into three subbasins for the Watershed Analysis conducted by the Forest Service (1995b). The analysis calculated that on National Forest Service lands harvesting has occurred on 36% of the riparian reserves within upper basin, 77 % of the riparian reserves within the middle basin, and 23% of the riparian reserves within the lower basin. Overall harvest rates for the Pine Creek subbasins were calculated at 75% for the upper basin, 69% for the middle basin, and 52% for the lower Basin (USFS 1995b). Only 7% of the lower

Cougar Creek basin has been harvested, while 50% has been harvested in the upper Cougar Creek basin (most of the upper basin is private property)(USFS 1995b).

Since about 1950, 28% of the "Middle Lewis River Watershed Analysis" area has been harvested. Rush Creek was divided into upper and lower subbasins for this analysis. Twenty-three percent of the entire upper Rush Creek subbasin and 13% of the upper basin riparian reserve has been harvested since 1950. In the lower Rush Creek subbasin, 49% of the entire subbasin and 23% of the riparian reserves has been harvested (USFS 1995b and 1995c).

Water Quality

The eruption of Mt. St. Helens affected water quality in the Muddy River and in Pine Creek. Riparian vegetation was destroyed and mud flows and ash deposits have contributed high levels of fine sediments to the stream. In November, 1994 turbidity was measured at 94 neophelometric turbidity units (NTUs) in the Muddy River, 36 NTUs in the Lewis River above Swift Reservoir, and 18 NTUs in Pine Creek (EA Engineering 1999). Stream temperatures above 16 degrees C have also been measured in Pine Creek. The causes of these elevated stream temperatures are not well understood. It is suspected that channel widening from high levels of timber harvest, and the 1980 mudflows and the loss of riparian vegetation from the St. Helens eruption, have all contributed to elevated stream temperatures in Pine Creek (USFS 1996b).

The Dolly Varden/bull trout that inhabit these waters have similar habitat preferences to other salmonids, only stricter (USFWS, 1998; WDFW 1998; R2 Resources 1999). Bull trout, more than any other salmonid species, require cold water to initiate spawning, and for incubation and rearing (USFWS 1998). Optimal spawning temperatures are under 9-10 degrees C, incubation temperatures range from 2-4 degrees C, and juvenile rearing temperatures are between 4 and 10 degrees C (USFWS 1998).

Water Quantity

The Forest Service as part of the "Lower Lewis River Watershed Analysis" conducted a peak flow analysis for various subbasins. This analysis models changes in stream discharge resulting from vegetation removal. These alterations to the hydrologic regime can alter channel characteristics by increasing streambed and/or streambank erosion, alter the supply of sediments to the channels, alter sediment and LWD storage and structure in channels, and alter energy relationships involving water temperature, snowmelt, and freezing (Chamberlin et al. 1991). For the lower Pine Creek subbasin, the Forest Service calculated potential increased peak flows between 12% to 22%. Potential increased peak flows in the middle Pine Creek basin were between 10% and 17% (USFS 1995b). Timber harvesting within the Rush Creek and Cougar Creek subbasins has not increased the potential peak flows over 10% (USFS 1995b and 1995c).

Another phase of the analysis examines the extension of the stream channel network by roads and ditch lines in roads. These factors may increase peak flows through road cut slope interception of subsurface flow and by routing surface waters through ditch lines as “pseudo” stream channels (Furniss et al. 1991). Extension of the stream channel network has increased by approximately 48% in the lower Pine Creek subbasin, adding to the potential for increased peak flows (USFS 1995b). The extension of the stream channel network by road construction has not substantially increased the potential for peak flows in the Rush Creek, or in the lower and upper Cougar Creek subbasins (USFS 1995b and 1995c).

The Washington State Department of Ecology (Caldwell 1999) collected “Toe Width” information on a number of tributaries to Lewis River including Cougar Creek in the upper watershed. This information can be used to establish the relationship between streamflows and available instream habitat for different species, even during various life-history stages. Stream gauge data is not available for Cougar Creek; however, spot flow data indicate that coho spawning flows were near optimal as were juvenile rearing conditions for all salmonids during the late summer and fall of 1998.

PacifiCorp surveyed habitat conditions in Panamaker Creek, Ole Creek, Rain Creek, Dog Creek, and Speelyai Creek in 1996. These studies revealed that all the streams except for Speelyai Creek experienced intermittent flow conditions in the fall of 1996, limiting available habitat.

Biological Processes

Since the construction of the dams, passage for anadromous fish has been blocked, and the river system is not receiving the input of nutrients from the ocean that it would have received historically. This could represent a major limiting factor to fish production within the upper Lewis River basin and an assessment of nutrient levels and cycling would provide important information for any reintroduction efforts above the dams.

Habitat Limiting Factors on the East Fork Lewis River

Access

The only barriers to anadromous passage within the mainstem East Fork Lewis River are Lucia Falls and other natural falls upstream. Sunset Falls (RM 32.7) was notched in 1982, opening up a significant amount of habitat in the upper watershed. Steelhead are the only species that consistently migrate past Lucia Falls. There are a number of passage problems on tributaries to the East Fork that are shown in the Historic Anadromous Distribution and Passage Barriers Map (Appendix A-3). The following is a list of other known access problems within the East Fork Lewis River watershed including:

- A partial to total barrier on McCormick Creek at NW LaCenter Road blocks approximately 2.3 miles (greater than 60 percent) of potential habitat for coho and winter steelhead.
- A total passage barrier on Brezee Creek just up from the mouth under Lockwood Road in LaCenter blocks access to 5.7 miles of potentially productive habitat. Other barriers in the Brezee Creek watershed include a dam 500 feet above Lockwood

Road, another culvert further upstream where 359th St. crosses Brezee Creek, and a blocking culvert on a tributary to Brezee that blocks 1.8 miles of potential habitat.
- A partially-blocking culvert occurs on a tributary to Lockwood Creek at Taylor Valley Road. There is a series of cascades just below this blockage, and it would be important to survey for coho above the cascades before spending funds to repair the upstream culvert. Some TAG members noted that the culvert improvements on Lockwood Creek at Lockwood Rd. might need modifications or at least consistent maintenance to allow full passage for all species.
- There are three culverts marked on Clark County's culvert inventory on a tributary to Mason Creek. There is also a culvert on Mason Creek under N.E. 102nd that has been classified as passable but that needs additional assessment to determine its status.
- Potential passage problems on Manley Road Creek need assessment.

There are a number of access problems that need assessment on Dean Creek including:
- Potential low-flow and thermal barrier passage problems near the mouth
- that may block 2.2 miles of potential habitat
- A culvert on a private property that may block passage near the mouth of
- Dean Creek.
- Mid-and late-summer flow is often subterranean in heavy gravel deposits
- just downstream of J.A. Moore Rd.
- A culvert farther up Dean Creek may block passage to 0.8 miles of
- habitat for coho, winter steelhead, and cutthroat.

Floodplain Connectivity

TAG members estimate that over 50% of the off-channel habitat and associated wetlands within the floodplains of the lower East Fork have been disconnected from the river. In 1854 era maps, nearly the entire river valley bottom was mapped as wetlands "subject to inundation," with extensive channel braiding from RM 7 to RM 10 (Collins 1997)(see Figure 2 from Norman et al. 1998). By 1937, the mainstem was mostly a single-thread channel with a system of ephemeral floodplain sloughs that remain from the former braided channels (Collins 1997). This conversion of the channel from braided to a mostly single thread morphology has substantially reduced the complexity of habitat and largely eliminated side channel and backwater habitats (Norman et al. 1998). These side channel and backwater habitats are especially important as overwintering and rearing areas for juvenile coho (Cederholm and Scarlet, 1981; Peterson 1982; Brown 1987; Bjornn and Reiser 1991). Also, the most dense observed spawning for chum salmon historically occurred in side channels and upwelling areas in the lower 10 miles of the East Fork Lewis River (WDF, 1973; Hawkins 1999, personal comm.) that are now largely disconnected from the river.

Diking, ditching, and draining of wetlands to protect and enhance agricultural, residential, and mining activities, (see dike locations in the Mass Wasting and Stream-

Floodplain Connection Map: Appendix A-4) has occurred on a number of floodplain properties including:

- Dikes disconnect the river from the floodplain along the north side of the river at LaCenter Bottoms (RM 3.3 to RM 4.5). This area has been extensively ditched and drained as well.
- Dikes run along the lower end of Lockwood Creek.
- A number of dikes disconnect the river from the floodplain on County owned properties along the south side of the river from RM 4.5 to RM 7. Drainage ditches drain wetlands and wall base channels in this area that help replenish groundwater throughout the year and provide overwintering habitat for coho juveniles;
- Remnant/discontinuous dikes run along the north side of the river across from the Ridgefield Pits near RM 8;
- Remnant dikes run along the County's property (referred to as the Zimmerly property) just downstream of the Ridgefield Pits near RM 7, reducing the connection between the river and downstream wetland and floodplain habitat;
- Just downstream of Dean Creek (near RM 7.2) dikes run along the north side of the river to protect Hamm's and Swanson's properties from flooding;
- Dikes protect the County's old gravel pit just upstream from the Ridgefield Pits near RM 9.4;
- Remnant dikes are left in mid-channel around the old RM 9 gravel pit; and
- Daybreak Dike on the south side of the river upstream from Daybreak Park near RM 12 disconnected a large overflow channel with floodplain habitat from the river.

<u>Bank Stability</u>
Bank stability is a major concern along certain reaches of the lower 14 miles of the river (see Mass Wasting and Stream-Floodplain Connection Map: Appendix A-4). According to the Soil Conservation Service (1972) between the City of LaCenter (RM 3) and Mason Creek (RM 6) the soils and channel materials consist mainly of silts and sands. The river's natural rate of lateral migration is high in these non-cohesive materials (Soil Conservation Service 1972). Between RM 6 and RM 10 the banks consist more of sand and gravel (WEST Consultant 1999). WEST Consultants (1999) estimated that long-term lateral channel migration rate in the vicinity of the Daybreak and Ridgefield Pits (near RM 8) was approximately 40 feet per year (see Table 22). However, relative rates of meandering and downcutting may accelerate if there are sudden and/or significant changes in the river through an avulsion into a gravel pit, or upstream levee construction (Norman et al. 1998). The avulsion of the East Fork into gravel pits near RM 9 in 1995 and into the Ridgefield Pits (RM 8) in 1996 has caused significant changes in bank and channel stability in the area, and in the sediment supply both upstream and downstream of the avulsions (Norman et al. 1998).

There is a significant amount of mass wasting occurring along the steep and unstable south bank of the East Fork from approximately RM 9.5 down to the Ridgefield Pits (RM 8). WEST Consultants (1999) contents that Daybreak Bridge (RM 10) fixes the river in its present location and helps direct downstream flow from the bridge toward the southern valley wall. At high flows, dikes protecting Clark County's gravel mines just upstream from RM 9 may also be directing the river towards the south cliffs further exacerbating erosion of the south cliffs (Dyrland 1999, personal comm.). Norman et al. (1998) states that the avulsions into the abandoned gravel pits have led to increased erosion along the south cliffs. According to Norman et al. (1998) the avulsion of the East Fork into these deep ponds has caused:

- approximately 10 feet of channel downcutting as the knickpoint has migrated upstream;
- increased erosion along the already generally unstable south banks,
- abandonment of approximately 4,900 feet of channel where salmon and steelhead had spawned, and
- sluggish flow through the ponds.

Whatever the cause, TAG members concur that this mass wasting is contributing excessive fine sediments to fall chinook spawning grounds. The Ridgefield Pits are also filling quickly. Of the estimated 2 million cubic yards of material needed to fill the 70 acre pits (Norman et al. 1998), approximately 385,000 cubic yards of material has already been deposited in the pits since the 1996 avulsion (West Consultants 1999). The time required for the river to re-establish equilibrium depends on the size and depth of the pit, the river's ability to transport sediment, and the availability of sediment (Norman et al. 1998). West Consultants (1999) estimated that it will take around 25 years for geomorphic recovery of this section of the river.

Table 22 - Channel Migration Rates in the East Fork Lewis River

Location	Type of Migration	Average Migration (ft/year)
RM 10 – RM 9.3	Lateral (side to side)	6
	Longitudinal (Up/Down Valley)	36
RM 9.3 – RM 9	Lateral (side to side)	6
	Longitudinal (Up/Down Valley)	9
RM 9	Lateral (side to side)	5 and 100*
	Longitudinal (Up/Down Valley)	-
RM 9 – RM 8	Lateral (side to side)	30
	Longitudinal (Up/Down Valley)	27
RM 8 – RM 7.5	Lateral (side to side)	-
	Longitudinal (Up/Down Valley)	42
RM 7.5 – RM 7	Lateral (side to side)	25
	Longitudinal (Up/Down Valley)	25

* Short-term channel migration between 1996 and 1998
Adopted from West Consultants 1999.

Comparison of aerial photos taken in November of 1997 (Figure 5 from Norman et al 1998), and photos taken taken in January of 2000 (Figure 6 from Dyrland 2000), point out the changes that have occurred in the Ridgefield Pits within just the last two years. Bank erosion and mass wasting from upstream reaches appears to have already filled in portions of the upper Ridgefield Pits to the point that distinct channels have formed within the pits (WEST Consultants 1999, personal comm.; Dyrland 1999, personal comm.). These channels are extremely dynamic, shifting position within the ponds over a hundred feet several times during the last year (Dyrland 1999 personal comm.). Norman et al. (1998) found that an avulsion into abandoned gravel mines on the Yakima River near Parker, Washington in 1996 developed somewhat similar characteristics. The river eventually formed a braided meandering course through the ponds as the shallow gravel ponds filled with sediments.

While the pits are filling, it would be expected that the sediment supply would be reduced downstream of the pits, possibly eroding the downstream channel and bars (R2 Resources 1999; Norman et al. 1998). However, instead of eroding channels and bars recent survey's show that gravel bars may be actually building below the ponds (see Figure 7 from Dyrland 2000). It appears that the river has sufficient competency to move at least significant portions of the large sediment load from mass wasting and channel instability above the avulsion to reaches below the Ridgefield Pits.

Some bank erosion is occurring below the Ridgefield Pits, especially between RM 7.1 and RM 7.5 (Dryland, 1999, personal comm.). Near RM 6.2, bank erosion has increased substantially widening the river channel and filling in pools (Dryland 1999, personal comm.). Richard Dyrland (1999, personal comm.) has measured width to depth ratios of over 30 to 40 near RM 6.2. Dyrland (1999, personal comm.) attributes this bank instability to a buildup of sediment in the channel bed, which increases shear stress on stream banks and eventually leads to increased width to depth ratios (Leopold et al.1964). Past agriculture and grazing practices, gravel mining and processing, and residential development between RM 3 and RM 9 has removed most of the riparian and floodplain vegetation. This vegetation helps stabilize the streambanks and moderate the erosion rate (Chamberlin et al. 1991). Only a few remaining spots of mature deciduous forest remain along the shoreline to help provide bank stability.

Bank stability is also a problem just upstream from Daybreak Park on the south side of the river near RM 10.5 and on the north side of the river just downstream and across from where the "Daybreak Dike" was reconstructed near RM 11.3 (see Appendix A-4). Like the south cliffs below Daybreak Park, some of these areas contain naturally unstable deposits. However, the channelization of the river, using dikes and bank armoring, may just move the channel and bank instability and flooding problems to downstream reaches (Norman et al. 1998; Rosgen 1996). Dyrland (1999, personal comm.) measured width to depth ratios within this area of the river that ranged from 30 to near 50, and he found evidence of large new gravel bars that are building. Excessive sediment inputs may be aggrading the riverbed in these areas and placing stress on the stream banks.

Figure 5 – Aerial Photo (November 1997) of Avulsion into Ridgefield Gravel Pits

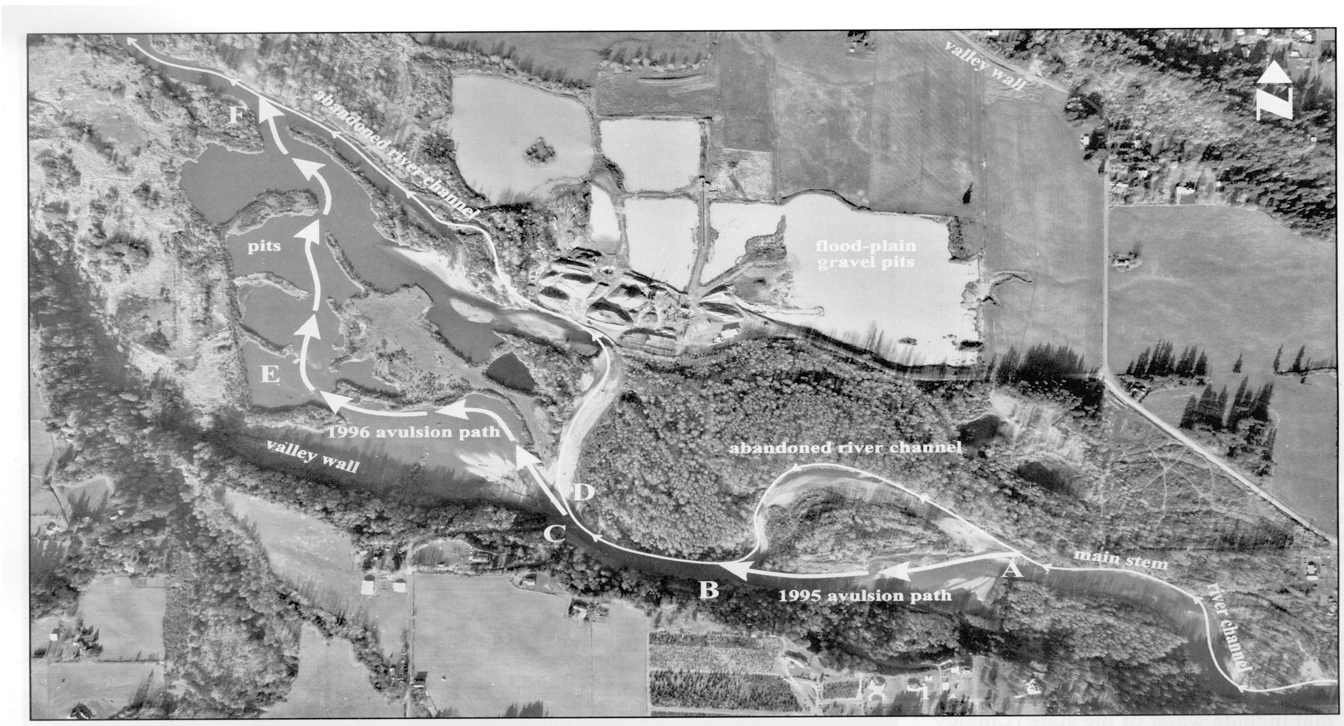


Figure 6 - January 2000 Aerial Photos of Ridgefield Pits

A number of other bank instability problem areas in the tributaries to the East Fork were noted by the TAG including;

Chronic mass wasting from the high cliffs on Mason Creek near the bridge at Anderson Rd. is adding excessive fine sediment to the stream.
Chronic sediment inputs from bank instability on lower Rock Creek above Rock Creek Rd. where cattle are grazing in the riparian area and stream.
Chronic mass wasting problems near Dole Valley Bridge on upper Rock Creek.
Chronic mass wasting problems on upper Lockwood Creek above Lockwood Creek Road and upstream of 379th St.

Large Woody Debris (LWD)
Large woody debris concentrations are below historic levels almost throughout the East Fork basin (USFS 1995a). On the East Fork Lewis River, LWD was removed from the channel and adjacent riparian areas through successive salvage operations following the Yacolt Burn, a large stand replacement fire that occurred in 1902. Large scale salvage logging started in the 1930's and continued for over three decades until much of the riparian area was logged, including woody debris within the stream channel. LWD was also removed from the stream channel in the 1980's, when all debris jams were mistakenly interpreted as fish migration barriers (USFS 1999). Over the last 15 years the LWD concentrations in the upper river have dropped even further (see Table 23). In rating the concentrations for LWD the Forest Service uses standards developed by the Columbia River Basin Policy Implementation Guidelines (PIG), with >80 pieces per mile of stream channel that are larger than 50 feet long and 36 inches DBH rated as good. Recent surveys in the upper East Fork Lewis found that 92 % of the surveyed streams had < 40 pieces of LWD per mile (a "poor" rating), and at least 98% of the streams surveyed have concentrations of LWD < 80 pieces per mile (USFS 1995a).

Table 23 - Changes in Large Woody Debris (LWD) Concentrations

Stream Survey Year	*Survey Length in Miles	LWD Pieces Per Mile
1983	4.2	39.0
1993	5.0	29.3
1998	5.2	12.4

*All surveys begin at Sunset Falls and go upstream.
(Adapted from USFS 1999)

TAG members also rated LWD concentrations as "poor' within most of the tributaries to the East Fork as well as the lower mainstem. Both Rock Creeks (upper and lower) and Cedar Creek have very limited supplies of LWD. Many of these systems also are "sediment supply limited," meaning that there is little influx of material from landslides and debris flows to replace gravels that are transported downstream during high flow events (USFS 1999). LWD supplementation in these tributaries is needed to help capture and concentrate sparse spawning gravels.

Potential recruitment of LWD is also a concern within the East Fork watershed. Riparian areas are slowly recovering from past fires and snag removal activities, but they still lack a large coniferous component. Most of the large wood component is composed of hardwoods, such as maple, alder and cottonwoods (USFS 1995a). While deciduous species will provide shade, nutrient inputs, and cover, only mature conifers will last long enough and remain stable enough as LWD in the stream to produce instream conditions that will provide a full range of benefits for fisheries (Hicks et al. 1991).

Pools

The lower 6 miles of the East Fork is a tidally influenced backwater of the Columbia River (Hutton 1995b). Between RM 6 and lower Rock Creek at RM 16.2 both the number of pools per mile and pool quality would fall within the "poor" category of the habitat standards used for this analysis (see Appendix B). A survey of instream habitat from Daybreak Park (RM 10.2) downstream to RM 7.0 found only three large pools (EnviroScience 1996). The width to depth ratios of the river channel in areas below the Ridgefield pits have been increasing over the last ten years and the few pools in this area have been filling with sediment (Dyrland 1999, personal comm.)

The river's avulsion into the Ridgefield Pits has created additional pool habitat in the lower river. However, these artificially deep and wide pool conditions are not generally beneficial to salmonids, as water temperatures within the pits may increase (see Table 25) (R2 Resources 1999) and as habitat for predatory warm water species may be enhanced (Norman et al. 1998). Aquatic habitats within these ponds need assessment to further describe the existing conditions and to explore potential impacts to anadromous species.

Above lower Rock Creek RM 16.2, pools per mile and pool area within the East Fork mainstem are mostly controlled by bedrock formations. Tag members rated the number of pools per mile as generally "fair" in the East Fork between lower Rock Creek (RM 16.2) and Sunset Falls (RM 32.7).

Stream surveys, measuring the pools per mile of stream channel in the upper East Fork (above RM 32.7), indicate that approximately 52% of the surveyed streams were rated as "poor," 6% were rated as "fair," and 42% were rated as "good" according to the Forest Service (PIG) standards (USFS 1995a). The East Fork has several large pools suitable for holding adult summer steelhead below the Green Fork confluence; however, many of these are removed from spawning sites and/or lack cover from predators. Quality holding pools are rare on Slide Creek, the Green Fork, and the upper East Fork above the confluence with the Green Fork (USFS 1999). This lack of quality pools places limits on the number of adult summer steelhead that can find refuge during the 12 months they can spend in the upper system before they spawn (USFS 1999).

Pool habitat data is lacking on most of the tributaries within the East Fork system. However, TAG members did rate both upper Rock Creek and Cedar Creek as having a "fair" number of pools per mile.

Side Channels

In 1854, nearly the entire valley bottom between RM 6 and RM 10 was mapped as wetland "subject to inundation," and the upstream portion of the reach included an extensive system of braided channels (see Figure 2 from Norman et al. 1998). By 1937, the mainstem was mostly a single-thread channel with a system of ephemeral floodplain sloughs that remain from the former braided channels (Collins 1997). Conversion of the channel from braided to a mostly single thread morphology has substantially reduced the complexity of habitat and largely eliminated side channel and backwater habitats (Norman et al. 1998).

Off-channel or high flow refugia in the form of side channels are rare but do exist along the upper East Fork, particularly in areas of lateral and mid-channel gravel bars. However, except during the highest flows, these side channels are either unavailable due to channel incision or have velocities too high for use by juvenile salmon (USFS 1999).

Substrate Fines

The lower 6 miles of the East Fork Lewis River is a flat, tidally influenced silt and sand bed stream (WEST Consultants 1999). From RM 6 to RM 10 the channel bed transitions to sand and gravel. Near Daybreak Bridge (RM 10) the East Fork emerges from a tightly confined canyon into an alluvial valley that ranges from 0.5 to 0.75 miles wide (see Figure 1: Profile of Lower and Middle East Fork Lewis from Hutton 1995b). The river gradient abruptly decreases in this area and sediments are deposited.

After the avulsion of the East Fork into the Ridgefield Pits, it is likely that sediment supply decreased to the downstream channel (West Consultants 1999), at least temporarily. While the pits are filling, it would be expected that the sediment supply would be reduced downstream of the pits, possibly eroding the downstream channel and bars (R2 Resources 1999; Norman et al. 1998). However, instead of eroding channels and bars, recent survey's show that gravel bars may be actually building below the ponds (see Figure 7)(Dyrland 1999, personal comm.). It appears that the river has sufficient competency to move at least significant portions of the large sediment load from mass wasting and channel instability above the avulsion to reaches below the Ridgefield Pits.

At least 4,900 feet of channel and spawning habitat for threatened fall chinook and winter steelhead has also been temporarily lost because of the avulsions into the Ridgefield pits (see Figure 5 from Norman et al. 1998). Historic reports observed that the highest density of spawning chum salmon in the Lewis River system also occurred within the lower reaches of the East Fork, just downstream of the Ridgefield Pits (WDF, 1973). Spawning habitat both upstream and downstream from the avulsion has been degraded from unstable channel conditions and changes in the sediment supply. The aquatic habitat conditions in this section of the river have been significantly altered and channel changes associated with this avulsion will likely continue to proliferate both upstream and downstream of the ponds for years to come (Norman et al. 1998).

Figure 7 - Gravel Bars Downstream of the Ridgefield Pits (RM 7)

Photo by Richard Dyrland January, 2000

Above the Ridgefield pits, erosion along the already unstable south cliffs appears to be contributing excessive fine sediments to the river. These sediments are quickly filling the abandoned Ridgefield gravel ponds (see Figure 4 from Dyrland 1999). Additional data is needed on the water quality, aquatic ecology, channel conditions, erosion rates, and sediment transport upstream, downstream, and within the Ridgefield Pits to document changes and impacts to habitat in this important reach.

Most of the river between Daybreak and Sunset Falls (RM 32) is a transport reach, with steep gradients and high water velocities that generally move fine materials out of this section to areas below Daybreak Bridge (Hutton 1995b). A sediment budget for the East Fork above Sunset Falls was developed for the USFS by the Pacific Watershed Institute. The sediment budget shows that the current supply of sediment in the upper East Fork channel is limited (USFS 1999). The rate of gravel production from landslides and road failures is low because most of the available material came down in the years immediately following the major fires 50-80 years ago. The limited supply of spawning gravels likely limits spawning sites within the upper river. LWD concentrations, that would help capture and store spawning gravels are also extremely limited within the upper river. Fine materials comprise the largest volume of any size sediment but are a very small portion of the channel bed, suggesting that this material is transported out of the upper river (USDA, 1999).

While there doesn't appear to be any major problems with excessive fine sediment in the upper river, sediment inputs and transport downstream could be adversely affecting response reaches in the lower river. Lewis County GIS (1999) measured 976 miles of road in the 236 square miles of East Fork Lewis River watershed, revealing a road density of 4.13 miles/square mile. As a surrogate measure of fine sediment inputs, road densities greater than 3 miles/square mile with numerous valley bottom roads are considered to fall in the "poor" category (see Salmonid Habitat Rating Standards in Appendices B). The overall road density in the upper watershed is approximately 1.79 miles of road per square mile, with 321 stream crossings. This road density would likely be categorized as either "good" or "fair" according to NMFS standards, depending on the number of valley bottom roads. However, road densities reach 4.6 miles per square mile in some subbasins, with as many as 30 road stream crossings in a single sub-basin (USFS 1995a). Using NMFS standards, six of the twenty-three Forest Service sub-basins have road densities that would be rated as "poor" and the cumulative sediment inputs could be impacting downstream habitat.

Riparian Conditions

Riparian habitat has been heavily impacted by grazing, farming, residential development and mining along the lower river below Daybreak Bridge (RM 10)(see Map A-14: Riparian Conditions). This highly dynamic area may never have had a riparian zone that contained a large proportion of mature conifers, but the area likely contained a multistory mix of cottonwoods, willows, ash, and riparian shrubs. What remains of the riparian overstory vegetation is mostly widely dispersed cottonwoods, willows, and ash. In the disturbed areas invasive species like reed canary grass, Himalayan blackberry, and Scotch broom have proliferated.

Significant riparian restoration efforts have begun on some of Clark County's open space properties within this area (see Map A-14). To date, over 2 miles of the shoreline has been replanted with a mix of native species, with plans to replant another 1.5 miles in the summer of 2000 (Tim Haldeman 1999, personal comm.). Riparian restoration efforts are also planned for the Ridgefield Pits. However, the conditions within the gravel pits are highly dynamic and assessments are underway to ensure that proposed restoration activities will benefit anadromous fish habitat in both the short- and long-term (Dygert 1999, personal comm.). More than 4,000 native trees and shrubs were planted in 1998 along 20 acres of riparian zone on the Storedahl property and additional plantings are planned for this year (R2 Resources 1999, personal comm.).

Analysis of aerial photos from 1996 shows that, in general, riparian conditions along the rest of the mainstem are "poor." Roads and residential development parallel the river for much of its length. It is not uncommon that most riparian vegetation along the river has been removed, with lawns running down to the river in their place. Only along some sections of the steep south bank of the river from Lucia Falls to upper Rock Creek is the riparian zone generally intact with some mature conifers (see Map A-14). Most of the tributaries to the East Fork also have "poor" riparian conditions. Some upper sections of

Brezee Creek, Riley Creek, Mason Creek, Dean Creek, and Cedar Creek are the exceptions.

Riparian canopy cover was assessed as part of the Upper East Fork Watershed Analysis (USFS 1995a). Large segments of the East Fork and Copper Creek lack canopies that cover 50% of the stream channel. For this report, these > 50% open canopy areas along the upper East Fork were included in the "poor" category with other riparian areas of WRIA 27 and mapped on Figure A-14. Large mature conifer trees are lacking in the streamside riparian zones almost throughout the upper watershed, and riparian areas are mostly dominated by deciduous species such as alder (USFS 1995a).

Water Quality

Water Quality is a large concern within the East Fork. In 1996, the East Fork Lewis River, from the mouth to Mouton Falls (RM 24.6), was listed under Section 303(d) of the Clean Water Act as an impaired waterbody due to water quality exceedances for temperature, pH, and fecal coliform (WDOE 1996). However, the 1998 candidate Section 303 (d) list included only exceedances for temperature and fecal coliform for the same reach of the river (WDOE 1998).

Hutton (1995a) measured water quality at nine different stations within the East Fork and various tributaries for a twenty-month period in 1991 and 1992 (see Table 24). Key findings from this monitoring program included:

- Across all monthly monitored subbasins, excessively high levels of fecal coliform were by far the most widespread water quality problem.
- High turbidity was the second most widespread water quality problem.
- Excessively high water temperature was a likely water quality concern most often in the lower main stem East Fork.
- Monthly low dissolved oxygen was a major issue only in Yacolt Creek and to a lesser extent in lower Rock Creek.
- McCormick Creek appears to be a unique subbasin based on relatively high values for all the parameters examined except water temperature and dissolved oxygen.
- For most of the monitored subbasins, phosphorus concentrations were below a threshold for nuisance plant growth.

High water temperatures during the summer months are one of the most important water quality issues on the lower East Fork (R2 Resources 1999). For Washington State Class A waters, like the East Fork, the temperature standard is 18 degrees C, and temperatures in the East Fork commonly exceed that level during the summer (Hutton 1995a, Ecology 1998a, and R2 Resources 1999). Temperatures above 15.6 degrees C and 17.8 degrees C are rated as "poor" by NMFS and in the Conservation Commission's Salmonid Habitat Condition Rating Standards (see Appendix B). The Ridgefield Pits, with their larger surface area than the previous channel, could be contributing to water temperature problems in the lower East Fork. R2 Resources (1999) wanted to test that hypothesis by measuring water temperatures above, within, and below the Ridgefield Pits (see Table 25). Water temperatures were higher within the Pits than in the river above or below the

Pits in measurements taken in April and August of 1998 (R2 Resources 1999). Water temperatures, as measured in August 1999, increase from Pit to Pit as the water flows downstream (see Table 25), suggesting cumulative water quality impacts within these large open water bodies. However, these temperature increases were not apparent downstream of the Pits just below Dean Creek.

Table 24 - Water Quality Exceedances in the East Fork Lewis River

Subbasin Monitoring Station	Percent of Measurements exceeding state criteria					Overall use support status
	Temp	DO	pH	Turbidity	Fecal Coliform	
McCormick Creek at NW LaCenter Rd.	10%	0%	0%	45%	60%	Not
Main stem near LaCenter Bridge	25%	5%	0%	10%	25%	Not
Lockwood Creek at Lockwood Cr. Rd.	5%	0%	0%	10%	45%	Not
Mason Creek at J.A.Moore Rd.	0%	0%	0%	0%	30%	Not
Main stem at Daybreak Park	20%	0%	0%	0%	0%	Partially
Rock Creek (lower) at NE Rock Cr. Rd	0%	10%	0%	30%	55%	Not
Main stem at Moulton Falls	0%	0%	0%	0%	25%	Not
Yacolt Creek at Co. Rd. 16	0%	50%	11%	0%	35%	Not
Rock Creek (upper) at Dole Valley Rd.	0%	0%	6%	0%	30%	Not

Adopted from Hutton 1995a

Water temperature monitoring within lower Dean Creek also revealed elevated temperatures during summer months (R2 Resources 1999). Water temperatures in Dean Creek adjacent to the Storedahl & Sons gravel processing ponds and below J.A. Moore Rd. have at times exceeded 24 degrees C (R2 Resources 1999). The lack of canopy cover in the lower reaches of Dean Creek and possibly groundwater connections to the large open water processing pits adjacent to the creek contribute to elevated water temperatures in this section of the creek.

Additionally, Dean Creek has been captured by the gravel processing ponds adjacent to the creek, contributing to elevated water temperatures and turbidity in Dean Creek. Between July 14 and August 31, 1999 temperatures of discharge water from Stordahl's processing ponds into Dean Creek, averaged 22.24 degrees C, with a minimum temperature of 20.80 degrees C, and a maximum temperature of 25.60 degrees C (Maul Foster & Alongi, Inc. 1999). Bjornn and Reiser (1991) state that although some salmonids can survive at relatively high temperatures, most are placed in life-threatening conditions when temperatures exceed 23-25 degrees C. National Marine Fisheries Service rates elevated water temperatures in the 15 to 17.8 degrees C range as providing poor habitat conditions for salmonids (see Appendix B).

Table 25 - Water Temperatures above, within, and below the Ridgefield Pits

Station	Temperature (in Degrees Celsius)			
	6 April 1998	**11-12 August 1998**	**24-25 September 1998**	**21 December 1998**
EFLR above Pits	9.3	19.0	16.4	0.2
EFLR within Pits	10.3	22.7	16.5	0.3
EFLR below Pits	9.0	21.3	16.9	0.4
		18 August 1999		
Pond 2		18.9		
Pond 3		19.2		
Pond 4		19.7		
Pond 5		19.9		
Pond 6		20.6		

Adapted from R2 Resources 1999
*Station above pits was located 0.5 miles below Daybreak Park; station below pits was below Dean Creek confluence. The 1999 data was recorded within the pit complex.

Between July 14 and August 31, 1999 monitoring of water quality parameters occurred at the outlet of these processing ponds to Dean Creek to measure changes in water quality from a new water treatment system that Storedahl & Sons is testing. The new system is intended to lower turbidity in discharge water to Dean Creek. Before this system was installed, turbidity levels were measured above 45 NTU in June 1998 and near 40 NTU in June 1999 (Maul Foster & Alongi, Inc. 1999). Turbidity levels decreased significantly during the time that the new system was being monitored, with an average turbidity of 12 NTU, a minimum of 6 NTU, and a maximum of 19 NTU (Maul Foster & Alongi, Inc. 1999). Collecting data on water quality parameters within Dean Creek below the discharge site from the processing ponds would help determine the extent of the potential impacts to salmonid habitat.

TAG members also suggested that farming operations in Fargher Lake area might be contributing to water quality problems within the lower Rock Creek basin. State standards for water quality were exceeded in lower Rock Creek for DO, turbidity, and fecal coliform in 10%, 30%, and 55% of the samples taken over an 20 month period from May 1991 through December 1992 (Hutton, 1995a). There is a need to assess water quality within the creek, and to investigate the possible connection between farming operations in Fargher Lake and water quality problems.

TAG members also noted some turbidity and possibly other water quality problems in Cedar Creek. The suspected sources are wastewater releases from Larch Mountain Corrections Facility and roads leading to the corrections facility. According to Rick Marlow (personal comm. 1999), over 200 cars per day are using the L-1400 road to the corrections facility. These roads are all gravel surfaced, and become slurry during the winter with the heavy traffic.

In the upper river, Forest Service surveys show that maximum daily water temperatures in the East Fork near Sunset Falls exceeded 16 degrees C on more than 40 days between June and September in 1997 and 1998 (USFS 1999). Temperatures exceeded 16 degrees C for 18 days in 1996, as well, without including measurements during August. Exceedances were also measured above Sunset Falls and in the Green Fork during 1996 and 1998 surveys.

Water Quantity

In June 1999, Washington Department of Ecology completed a streamflow study for the East Fork Lewis River and 13 smaller streams in Water Resources Inventory Area 27 (WIRA 27) to address available salmonid habitat at various stream flows. Ecology conducted this study to provide information to determine minimum stream flows in the WRIA as is required by state law. Table 26 provides data on the percent of optimum habitat available at various flows in the East Fork (Caldwell et al. 1999).

The Department of Ecology used the Instream Flow Incremental Methodology (IFIM) to measure conditions within the East Fork Lewis River and the “Toe Width” method for 13 tributary streams. Both are standard methods and a description is available in Publication #99-151 from Ecology (Caldwell et al. 1999). The IFIM estimates available habitat for various salmonid species as percent of optimal habitat as stream discharge varies. Using the IFIM model, a weighted useable area (WUA) for fish spawning and rearing is calculated using 4 variables, depth, velocity, cover and substrate. The WUA varies by species and life stages as flow changes. Optimal stream flow can then be determined by considering spawning and rearing flow requirements for various species.

Streamflow data from the East Fork Lewis River is available from the U.S. Geological Survey (USGS) for a 64-year period of record as measured at River Mile 20.2, 1.5 miles northeast of Heisson. Transects, measured for the IFIM analysis, were taken at approximately River Mile 11. Streamflow data from the USGS site is considered representative of the Transect site 9 miles downstream. Spot stream flow measurements were taken in tributaries during the late summer and early fall (see Table 27).

Table 26 - Percent of Optimum Habitat (WUA) at various flows East Fork Lewis River

Flow in cfs	Steelhead Spawning Habitat	Steelhead Juvenile Habitat	Chinook Spawning Habitat	Chinook Juvenile Habitat	Coho Spawning Habitat
705	84%	81%	82%	48%	67%
650	90%	86%	88%	51%	70%
600	93%	90%	94%	55%	75%
580	94%	91%	96%	58%	77%
560	95%	93%	98%	61%	79%
540	97%	95%	99%	64%	81%
520	98%	96%	100%	66%	84%
500	99%	97%	100%	69%	86%
480	100%	98%	100%	73%	90%
460	100%	99%	99%	76%	92%
440	99%	100%	99%	78%	94%
420	98%	100%	98%	81%	95%
400	97%	100%	95%	84%	96%
380	96%	100%	92%	87%	97%
360	94%	99%	89%	89%	98%
340	92%	97%	84%	92%	100%
320	89%	95%	79%	94%	100%
300	86%	93%	73%	96%	99%
280	82%	90%	68%	98%	98%
260	78%	87%	63%	100%	97%
240	74%	83%	58%	100%	95%
220	70%	78%	54%	100%	93%
200	66%	73%	49%	100%	90%
175	60%	65%	44%	98%	86%
150	54%	57%	38%	94%	81%
125	47%	50%	32%	86%	74%
100	40%	42%	26%	71%	63%
70	31%	34%	20%	37%	46%
50	23%	27%	15%	26%	31%
14	4%	15%	1%	11%	6%

Caldwell et al. 1999

Table 27 - Toe Width Flows for East Fork Lewis River Tributaries

Stream Name	Tributary to	Average Toe Width (in feet)	Toe-Width Flow for Fish Spawning and Rearing (in cfs)					
			Chinook Spawning	Coho Spawning	Chum Spawning	Steelhead Spawning	Steelhead Rearing	Salmon Rearing
Gee Creek (@ Ridgefield, HWY 501 crossing)	Lake River to Columbia River	17.3	46.6	23.0	46.6	42.3	9.4	8.4
Jenny Creek (@ Pacific HWY/Clark Co. Rd)	EF Lewis River	15	39.1	19.1	39.1	35.9	7.7	6.9
McCormick Creek (@ 11th Ave. crossing	EF Lewis River	12.3	30.6	14.7	30.6	28.5	5.8	5.2
Breeze Creek (W La Center, Co. Rd 42 crossing)	EF Lewis River	16	42.3	20.8	42.3	38.6	8.4	7.5
Lockwood Creek (@ Co. Rd 42)	EF Lewis River	21.3	60.4	30.2	60.4	53.9	12.6	11.4
Mason Creek (@ J.A. Moore Rd crossing)	EF Lewis River	17.3	46.6	23.0	46.6	42.3	9.4	8.4
Yacolt Creek (@ confluence at Moulton Falls)	EF Lewis River	35.5	113.7	59.0	113.7	97.4	26.1	23.7
Rock Creek (#1) (1/2 mi. south of Dole)	EF Lewis River	42.7	143.0	75.2	143.0	120.7	33.9	31.0
Rock Creek (#2) (@ 319th St Bridge off HWY 503)	EF Lewis River	17.5	47.3	23.4	47.3	42.9	9.5	8.6

Adapted from Loranger 1999

By comparing IFIM results with USGS streamflow data, it is apparent that East Fork Lewis River has limited spawning habitat for chinook in October. Chinook begin spawning in October when median stream flows are approximately 100 cubic feet per second (cfs), an estimated 25% of the optimal flow for spawning at this time of year (see Table 26). By the first of November, median flows approach 300 cfs which are near optimal flows for coho spawning and 80% of optimal flows for Chinook spawning. Summer steelhead spawn in March through June in the river and median flows are near optimal range for this species in the spring (Loranger 1999).

Juvenile rearing habitat in the stream is limited by low stream flows in the June through November period, with flows being only about 30% of the optimal flow in August and September, when median stream flows are 50 to 75 cubic feet per second.

Spot flow data indicate that spawning and rearing habitat for all salmonids was also severely limited in McCormick Creek, Breeze Creek, Lockwood Creek, Mason Creek, Yacolt Creek, and Gee Creek during the fall of 1998. The two Rock Creek stations had flows significantly lower than would be optimal for fall spawners. However, juvenile rearing conditions were near optimal during the fall of 1998.

It is apparent the pronounced seasonality of precipitation distribution and the subsequent streamflow is significantly limiting fisheries habitat and hence potential fish production in the summer and fall months in the East Fork Lewis River, and in many of its tributaries (Loranger 1999). These low summer flows also contribute to higher water temperatures and can slow migration into the upper river spawning grounds.

Table 28 - East Fork Lewis River Tributary Spot Measurements

WRIA 27 Measured Flows (in cfs)			
Date	9/10/98	10/9/98	11/9/98
EF Lewis River Tributaries			
Jenny Creek @ Pacific HWY/Clark Co. Rd	0.3	0.6	1.9
McCormick Creek @ 11th Ave. crossing	0.2	0.4	2.4
Breeze Creek @ LaCenter	0.7	1.0	1.9
Lockwood Creek @ Co. Rd 42	0.7	1.4	5.9
Mason Creek @ J.A. Moore Rd Crossing	0.3	0.6	5.1
Yacolt Creek @ confluence at Moulton Falls	3.9	7.4	16.0
Rock Creek (upper) 1/2 mi. south of Dole	5.0	22.9	24.0
Rock Creek (lower) @ 319th St off HWY 503	0.2	1.9	6.3
Lake River Tributary			
Gee Creek @ HWY 501	0.6	1.2	2.7

From Loranger 1999

High road densities have increased the stream channel network, which can lead to increased peak flows in the East Fork (USFS 1995a). The USFS (1995a) conducted a peak flow analysis that modeled changes in discharge resulting from vegetation removal and the extension of the stream channel network by roads and ditch lines. The study found that peak flow increases in nine of the twenty-three subbasins within the upper East Fork could reach 10% or greater for an average two-year storm. Road density is high in the entire East Fork watershed (4.13 miles/square mile), increasing the stream channel network and likely leading to the potential for increased peak flows throughout the basin.

<u>Biological Processes</u>
The Conservation Commission is using the number of stocks meeting escapement goals as a surrogate measurement of nutrient levels within stream systems. Three stocks of salmon and steelhead (coho, winter steelhead, summer steelhead) have not reached

escapement goals in recent years, and of all the stocks in the river only fall chinook runs were considered healthy by the 1992 SASSI report (WDF/WDW 1993; WDFW 1998). Fisheries biologists at WDFW Region 5 are unsure whether East Fork Lewis River fall chinook stock status is still healthy today (Shane Hawkins 1999 personal comm.). Escapement goals have not been established for chum salmon; however, WDF (1951) estimated an average escapement of 3,000 chum salmon to the Lewis River in 1951. Very few chum have returned to the East Fork in recent years. The number of carcasses of all anadromous species contributing nutrients to the East Fork watershed is below historic levels, and low nutrient levels may be limiting production.

A nutrient enhancement program is underway on the North and East Fork Lewis River systems. In 1997, WDFW and volunteer groups planted 1407 fish carcasses in tributaries to the North and East Forks of the Lewis River. In 1998, they planted 4,659 carcasses (Hale 1999, personal comm.).

ASSESSMENT OF HABITAT LIMITING FACTORS

Recommendations by Habitat Factors

In order to develop a set of standards to rate salmonid habitat conditions, several tribal, state, and federal documents that use some type of habitat rating system were reviewed (see Table 30 in Appendix B). The goal was to identify appropriate rating standards for as many types of limiting factors as possible, with an emphasis on those that could be applied to readily available data. Based on the review, it was decided to rate habitat conditions into three categories: Good, Fair, and Poor. For habitat factors that had wide agreement on how to rate habitat condition, the accepted standard was adopted by the Washington Conservation Commission (WCC). For parameters that had a range of standards, one or more of them were adopted. Where no standard could be found, a default rating standard was developed, with the expectation that it will be modified or replaced as better data become available.

The ratings adopted by the WCC are presented in Table 31. These ratings are not intended to be used as thresholds for regulatory purposes, but as a coarse screen to identify the most significant limiting factors in a WRIA. They also will hopefully provide a level a consistency between WRIAs that allows habitat conditions to be compared across the state. However, for many habitat factors, there may not be sufficient data available to use a rating standard or there may be data on habitat parameters where no rating standard is provided. For these factors, the professional judgment of the TAG was used to assign the appropriate ratings.

The Technical Advisory Group (TAG) for WRIA 27 developed Table 29 (Habitat Limiting Factors by Subbasin) using Table 31 in Appendix B as a guide to rate habitat conditions within WRIA 27. The information for Table 29 came from both published and unpublished studies, and the personal and professional experiences of TAG members. Within some subbasins, both personal experience and quantitative data was lacking. These areas are identified with a ND (no data) designation. Following Table 29 are recommendations from the TAG for addressing habitat limiting factors in each subbasin (the Kalama River, the Upper and Lower Lewis River, and the East Fork Lewis River). These recommendations were not prioritized by the TAG. TAG members felt that prioritization would require the further development of a standardized methodology that could be applied within as well as across basins.

WRIA 27

There were a number of recommendations that were not specific to individual subbasins and that apply across the entire WRIA including:

- Various land uses practices have substantial impacts on habitat conditions for anadromous salmonids. The TAG suggests that ordinances regulating surface mining and processing, rural and urban development, stormwater and erosion control, agriculture, and vegetation management within critical riparian zones be assessed and updated to ensure protection of habitat for threatened and endangered species.

- Assess, repair, and where possible, decommission roads that are contributing chronic sediment to stream systems or that may fail and lead to landslides, especially within areas with road densities above 3.0 miles/square mile.
- Look for opportunities, both short- and long-term, to increase Large Woody Debris (LWD) supplies within stream systems. Almost every stream system within WRIA 27 has below standard concentrations of LWD. Supplementation of LWD would help collect spawning gravels, enhance pool habitat, create habitat diversity and cover for salmonids, and stabilize stream channels.
- Loss of stable instream LWD will contribute to loss of sediment storage sites, fewer and shallower scour pools, and less effective cover for rearing fish (Chamberlin et al. 1991).
- Riparian restoration is needed almost throughout WRIA 27. However, many areas are in the process of recovering and now contain early successional deciduous species that at least provide shade and other riparian functions. Long-term goals should include speeding the recruitment of mature conifers within riparian areas.
- Look for ways to reduce excessive water temperatures in WRIA 27, especially within Cedar Creek (a North Fork Lewis tributary) and within the East Fork Lewis River.
- In general, look for ways to augment stream flows in WRIA 27 during low-flow periods. Initial analysis of available salmonid habitat at various stream flows within the stream systems of WRIA 27 shows that habitat is often limited during low-flow periods in the summer and early fall (Loranger 1999).

Kalama River

Access

- Address potential low-flow and thermal passage problems on the bar at the mouth of the Kalama, by forming partnerships with the Port of Kalama and other interested parties to first assess the extent of the problem and then look for both short- and long-term solutions.
- Assess and look for solutions to gravel and debris buildup near the mouths of other tributaries in the upper river, as these deposits may be inhibiting access in areas and reducing available habitat. The gravel buildup at the mouth of Langdon Creek was considered the highest priority problem, as flow becomes subsurface during the summer months in the coarse gravel deposits at the mouth.
- Access passage problems occur during low flows on Hatchery (Fallert) Creek at the hatchery. Hatchery Creek contains a substantial amount of the limited tributary habitat available for coho and winter steelhead within the lower Kalama basin.

Floodplain Connectivity

- Look for opportunities to increase and enhance off-channel and rearing habitat within the lower Kalama River. Off-channel habitat is naturally limited by steep gradients in many areas of the Kalama basin, and compounding the problem, most of the historic lower floodplain has been diked and disconnected from the river. This condition is likely a major limiting habitat factor for natural coho production within the basin.

Table 29: Habitat Limiting Factors by Subbasin

Stream Name	WRIA Index	Fish Passage	Floodplain Connectivity	Bank Stability	LWD	Pools Ratio Pools/mile	Side Channels	Substrate Fines	Riparian	Water Quality	Water Quantity	Biological Processes
Lewis River (Lower)	**270168**	**G (2)**	**P (3)**	**G (2)**	**P (2)**	**G (2)**	**P (2)**	**ND**	**P (3)**	**F (2)**	**G (2)**	**P (1)**
Gee creek	**270168.01**	**F (2)**	**P (2)**	**P (2)**	**P (2)**	**ND**	**ND**	**ND**	**P (3)**	**ND**	**P (1)**	**P (1)**
Lower East Fork (to RM 6)	**270173**	**G (2)**	**P (2)**	**P (2)**	**P (2)**	**NA**	**P (1)**	**P (2)**	**P (3)**	**P (1)**	**P (1)**	**P (1)**
MCCormick Cr.	**270182**	**P (1)**	**F (2)**	**ND**	**ND**	**ND**	**ND**	**P (2)**	**P (3)**	**P (1)**	**P (1)**	**P (1)**
Brezee Cr.	**270186**	**P (1)**	**ND**	**ND**	**ND**	**ND**	**ND**	**F (2)**	**F (3)**	**ND**	**P (2)**	**P (1)**
Lockwood Cr.	**270189**	**P (1)**	**P* (2)**	**P (2)**	**F (2)**	**ND**	**P (2)**	**P (2)**	**P (3)**	**P (1)**	**P (1)**	**P (1)**
Mason Cr.	**270200**	**P (1)**	**P (2)**	**P (2)**	**P (2)**	**ND**	**ND**	**P (2)**	**P (3)**	**P (1)**	**P (1)**	**P (1)**
EF (RM 6 to 16.2)	**270173**	**G (2)**	**P (1)**	**P (1)**	**P (2)**	**P (1)**	**P (1)**	**P (2)**	**P (3)**	**P (1)**	**P (1)**	**P (1)**
Dean Cr.	**270214**	**P (1)**	**P (2)**	**P (1)**	**P (2)**	**ND**	**ND**	**P (1)**	**P (3)**	**P (1)**	**P (1)**	**P (1)**
Mill Creek	**270218**	**G (2)**	**NA**	**ND**	**P (2)**	**P (2)**	**ND**	**P (2)**	**P (3)**	**ND**	**ND**	**P (1)**
Rock Cr. (Lower)	**270222**	**G (2)**	**NA**	**P (2)**	**P (2)**	**P (2)**	**ND**	**P (2)**	**P (3)**	**P (1)**	**ND**	**P (1)**
EF (RM 16.2 to 32)	**270168**	**G (2)**	**NA**	**F (2)**	**P (2)**	**F (2)**	**F (2)**	**F (2)**	**P (3)**	**P (1)**	**P (1)**	**P (1)**
Rock Cr. (Upper)	**270254**	**G (2)**	**NA**	**F (2)**	**P (2)**	**F (2)**	**F (2)**	**G (2)**	**P (3)**	**P (1)**	**F (2)**	**P (1)**
Cedar Cr.	**270260**	**G (2)**	**NA**	**F (2)**	**P (2)**	**F (2)**	**P (2)**	**F*** (2)**	**P (3)**	**P (2)**	**F (2)**	**P (1)**
EF (RM 32 to Head)	**270173**	**G (2)**	**NA**	**F (1)**	**P (1)**	**P (1)**	**P (2)**	**F*** (1)**	**P (1)**	**P (1)**	**P (1)**	**P (1)**
King Cr.	**270272**	**G (2)**	**NA**	**ND**	**P (1)**	**ND**	**ND**	**F (1)**	**F (1)**	**ND**	**F (1)**	**P (1)**
Slide Cr.	**270284**	**G (2)**	**NA**	**ND**	**P (1)**	**P (1)**	**ND**	**F (1)**	**P (1)**	**ND**	**P (1)**	**P (1)**
Green Fork	**270287**	**G (2)**	**NA**	**ND**	**P (1)**	**ND**	**ND**	**F (1)**	**F (1)**	**ND**	**F (1)**	**P (1)**
Lewis River (Woodland/RM 15)	**270168**	**G (2)**	**NA**	**G (2)**	**P (2)**	**F (2)**	**F (2)**	**G (1)**	**P (3)**	**G (1)**	**F****	**P (1)**
Robinson Cr.	**270300**	**P (2)**	**NA**	**ND**	**ND**	**ND**	**ND**	**P (2)**	**P (3)**	**ND**	**ND**	**P (1)**
Ross Cr.	**270305**	**P (2)**	**NA**	**ND**	**ND**	**ND**	**ND**	**F (2)**	**P (3)**	**ND**	**ND**	**P (1)**
Houghton Cr	**270319**	**ND**	**NA**	**ND**	**ND**	**ND**	**ND**	**ND**	**P (3)**	**P (2)**	**ND**	**P (1)**
Johnson Cr.	**270327**	**P (2)**	**NA**	**ND**	**ND**	**ND**	**ND**	**ND**	**P (3)**	**P (2)**	**ND**	**P (1)**
Lewis River (RM 15 to Dam)	**270168**	**G (2)**	**NA**	**G (2)**	**P (2)**	**G (2)**	**F (2)**	**G (1)**	**F (3)**	**G (1)**	**F ** (2)**	**P (1)**
Colvin Cr.	**270392**	**P (2)**	**NA**	**ND**	**F (2)**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P (1)**
Cedar Creek	**270339**	**F (2)**	**NA**	**F (2)**	**P (2)**	**F (2)**	**P (2)**	**P (2)**	**P (3)**	**P (1)**	**P (2)**	**P (1)**
SF Chelatchie Cr.	**270373**	**G (2)**	**G (2)**	**F (2)**	**P (2)**	**P (2)**	**ND**	**P (2)**	**P (3)**	**F (2)**	**F (2)**	**P (1)**
. NF Chelatchie Cr	**NA**	**G (2)**	**NA**	**F (2)**	**P (2)**	**F (2)**	**ND**	**P (2)**	**P (3)**	**G (1)**	**F (2)**	**P (1)**
. Pup Cr	**270345**	**F (1)**	**NA**	**ND**	**ND**	**ND**	**ND**	**ND**	**P (3)**	**ND**	**ND**	**P (1)**
Lewis Riv. (upper)	**270168**	**P (1)**	**NA**	**ND**	**ND**	**ND**	**ND**	**F (1)**	**ND**	**ND**	**ND**	**P (1)**

Table 29 Continued: Habitat Limiting Factors by Subbasin

Stream Name	WRIA Index	Fish Passage	Floodplain Connectivity	Bank Stability	LWD	Pools Ratio Pools/mile	Side Channels	Substrate Fines	Riparian	Water Quality	Water Quantity	Biological Processes
Cougar Cr.	**270479**	**G (1)**	**NA**	**F (1)**	**ND**	**ND**	**ND**	**F (1)**	**F (1)**	**ND**	**G (1)**	**P (1)**
Pine Creek	**270514**	**G (1)**	**NA**	**F (1)**	**P (1)**	**G (1)**	**ND**	**P (1)**	**P (1)**	**P (1)**	**P (1)**	**P (1)**
Muddy River	**270517**	**G (1)**	**NA**	**ND**	**P (1)**	**ND**	**ND**	**P (1)**	**ND**	**P (1)**	**ND**	**P (1)**
Rush Creek	**270538**	**G (1)**	**NA**	**ND**	**G (1)**	**G (1)**	**ND**	**F (1)**	**F (1)**	**G (2)**	**G (1)**	**P (1)**
Kalama Riv. (lower)	**270002**	**P (2)**	**P (2)**	**F (2)**	**P (2)**	**F (2)**	**P (2)**	**P (2)**	**P (2)**	**P (2)**	**P**	**P (1)**
Hatchery Cr.	**270017**	**P (2)**	**NA**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P (1)**	**ND**	**P (1)**
Spencer Cr.	**270004**	**F (2)**	**NA**	**P (2)**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P (1)**
Upper Kalama	**270002**	**P (2)**	**NA**	**G (2)**	**P (2)**	**G (2)**	**F (2)**	**F (2)**	**P (3)**	**ND**	**F (2)**	**P (1)**
Little Kalama R.	**270046**	**F (2)**	**NA**	**ND**	**ND**	**ND**	**ND**	**ND**	**P (3)**	**ND**	**ND**	**P (1)**
Wild Horse Cr.	**270065**	**P* (2)**	**NA**	**G (2)**	**P (2)**	**ND**	**ND**	**ND**	**P (3)**	**ND**	**P (2)**	**P (1)**
Gobar Cr.	**270073**	**F (1)**	**NA**	**ND**	**P (2)**	**F (2)**	**ND**	**ND**	**P (3)**	**ND**	**ND**	**P (1)**
Arnold Cr.	**270084**	**F (2)**	**NA**	**ND**	**P (2)**	**P (2)**	**ND**	**P (2)**	**P (3)**	**ND**	**ND**	**P (1)**
North Fork Kalama	**270124**	**P (2)**	**NA**	**P (2)**	**P (2)**	**F (2)**	**ND**	**ND**	**P (3)**	**ND**	**P (2)**	**P (1)**
Schoolhouse Cr.	**270139**	**P (1)**	**P (1)**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P (1)**
Bybee Cr.	**270142**	**P (1)**	**P (1)**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P (1)**
Burris Cr.	**270151**	**P (1)**	**P (2)**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**P (1)**

P = "Poor" as defined in Appendix A (Salmonid Habitat Condition Rating Standards)
F = "Fair" as defined in Appendix A (Salmonid Habitat Condition Rating Standards)
G = "Good" as defined in Appendix A (Salmonid Habitat Condition Rating Standards)
ND = No Data for this specific Habitat Condition in this subbasin.
NA = Not applicable to this Subbasin

(1). Quantitative studies or published reports documenting the habitat limiting factor
(2). Personal and professional experiences of TAG members.
(3). Riparian Habitat Conditions rated by analysis of aerial photos.
* *Restoration practices are planned to address this problem.*
** *Altered hydraulic regime due to the dams .*
*** *Lack of spawning gravels*

Streambed Sediment Conditions

- Continue to assess and repair or decommission roads that are contributing chronic sediment to the system or that may fail and lead to landslides. As part of the Forest and Fish Report agreements road maintenance and abandonment plans will become mandatory for all private and State lands. These plans will inventory and assess the condition of all roads (including orphan roads) and provide for (i) the routine, on-going maintenance of existing roads (not including orphan roads) including maintenance plans to address storm events; (ii) the repair of roads (other than orphan roads) and related fish passages in substandard condition; and (iii) the abandonment of certain roads (other than orphan roads). However, in some cases it may take up to 15 years under this agreement for landowners to fully implement these plans and provide protection for critical habitat.

Channel Conditions

- In general, LWD abundance is extremely low within the Kalama River basin. LWD supplementation would benefit habitat conditions for salmonids within many of the tributaries and possibly within the mainstem itself. However, sites for placement of LWD should be chosen only after careful consideration of the potential success of the project. TAG members suggested that high-gradient systems like the North Fork Kalama may not hold most LWD projects. It will also be important to speed recruitment of conifers within the riparian zones of the productive tributaries to provide future supplies of LWD and other riparian functions.
- Minimize the amount of clear-cutting that is occurring within the basin at any one time, as well as reduce the road density. Extensive clear-cutting (Chamberlin et al. 1991) and high road densities (Furniss et al. 1991) may increase peak flows within a basin, which may contribute to structural changes in the channel form, increase channel instability, and increase sediment delivery to the stream. High flows are likely contributing to the buildup of excessive sediments and debris near the mouths of tributaries in the upper Kalama.

Riparian Conditions

- Replant degraded riparian areas with native conifers to provide shade, increase channel stability, filter fine sediments, and provide a future LWD supply. Focus riparian restoration efforts on the most productive, yet degraded tributaries in the upper watershed (Gobar Creek, Wildhorse Creek, North Fork Kalama, Langdon Creek, and Lakeview Peak Creek).

Water Quality

- Suggest that Cowlitz County develop stormwater and erosion control ordinances that would help limit potential impacts to water quality from high levels of development occurring within the basin.

- Reduce road densities within the basin. Road construction increases the frequency of slope failures, as well as increases surface erosion (Furniss et al. 1991) which increases turbidity and suspended sediments.

Water Quantity

- It will be important to maintain a significant amount of the Kalama watershed in a forested condition. Lack of hydrologic maturity is considered a major problem in the basin contributing to a number of limiting factors (WDW 1990; USFS 1996, WDFW 1998). Most of the basin was logged and an extensive road network was built in a matter of a decade. Extensive logging and road construction within a basin can increase peak flows, and after a few years of regrowth, may even exacerbate low summer flows (Chamberlin et al. 1991). Since 95% of the watershed is owned and operated by private timber companies that generally harvest on a 35-50-year rotation, the harvesting cycle and resulting impacts to salmonid habitat may soon begin again.

Additional Studies

- Continue to fund adult trapping and smolt monitoring projects underway at the Kalama Falls Hatchery. These studies provide important data on the condition of the stocks and the effectiveness of fish management and restoration efforts.
- Conduct physical surveys of stream reaches within the basin to collect information on site-specific habitat conditions and fish usage. Very little specific data was available that could help quantify habitat conditions within the Kalama basin. This information is necessary to better identify what truly is limiting production of salmonids within the basin.

Dissenting Opinions

- Fred Palmer, a member of the TAG representing the Kalama Sportsman Club, wanted to state the opinion that Club members considered commercial harvest the most important factor limiting production in the Kalama basin. However, he was in agreement with the rest of the group on the list of habitat limiting factors that was developed in the report.

Lower Lewis River (to Merwin Dam)

Access

- Continue to look for ways to pass fish, both upstream and downstream, through the dams to gain access to approximately 80% of the historic anadromous habitat within the Lewis River (North Fork) basin. Historically, the areas above the dams provided important spawning and rearing habitat for summer steelhead, coho, and spring and fall chinook populations.
- Assess and then prioritize the replacement or repair a number of passage problems on the lower reaches of Ross, Johnson, Colvin creeks on the North Fork Lewis, and Brush, Beaver and Unnamed (RM 10.3) creeks on Cedar Creek.

Floodplain Connectivity

- Look for opportunities within the lower floodplain of the Lewis River to reconnect the river to off-channel and floodplain habitats. Almost the entire lower floodplain of the Lewis River has been disconnected from these critical rearing and over-wintering habitats for juvenile salmonids.
- Protect and enhance the limited amount of wetlands and off-channel habitat that provide important rearing areas for salmonid juveniles within Cedar Creek. Wetland complexes in the lower two miles of the South Fork Chelatchie Creek may provide the most significant areas to focus protection and enhancement efforts.

Streambed Sediment Conditions

- Reduce the amount of fine sediment inputs to the Cedar Creek system. Substrates within the system are cemented with fine sediments reducing the available spawning habitat. Suggestions included fence and replant degraded riparian areas, decommission unnecessary roads, reduce impervious surfaces, and create instream structures that will help collect scarce spawning substrates.

Channel Conditions

- Assess LWD concentrations and determine where there would be appropriate areas to supplement LWD in tributaries of the Lewis River. LWD concentrations are well below standards almost throughout the Lewis River system, and the appropriate placement of LWD would help collect spawning gravels, enhance pool habitat, create habitat diversity and cover for salmonids, and stabilize stream channels.

Riparian Condition

- Replant degraded riparian areas with native conifers to help reduce sediment delivery to the streams, to provide shade and reduce water temperatures, and to speed recruitment of conifers for a future supply of LWD.

Water Quality

- Address land use activities along Cedar Creek and its' tributaries that contribute to water quality problems (especially temperature). Specifically, maintain adequate riparian areas along all stream systems to buffer streams from adjacent land uses, fence livestock away from riparian areas, replant degraded riparian areas with native conifers and shrubs, and reduce road densities and impervious surfaces.

Water Quantity

- Continue to assess flow regimes and ramping rates on the Lewis River hydroelectric projects to assure protection of steelhead, and chum and coho salmon populations, as well as for fall chinook.
- Look for ways to augment stream lows in Cedar Creek to increase and enhance limited juvenile rearing habitat during low-flow periods (summer and early fall months).

Additional Studies

- Continue to fund the trapping and monitoring program that is already underway on Cedar Creek. These studies provide important data on the condition of the stocks and the effectiveness of fish management and restoration efforts.
- Survey small tributaries to Cedar Creek for illegal dams and diversions that may negatively influence water quality, water quantity, the movement of sediment, and the passage of fish. Enforce existing regulations that prohibit these structures.

Upper Lewis River (above Merwin Dam)

General Habitat Conditions

- Pine Creek provides critical spawning and rearing habitat for “threatened” populations of bull trout. The eruption of Mt. St. Helens has removed large areas of riparian vegetation and increased sediment inputs to the stream and increased turbidity. Monitor water quality, look for ways to repair riparian areas, stabilize stream banks, and decrease road densities within Pine Creek watershed.

Additional Studies

- As part of the relicensing process, a number of studies are underway that should provide additional data on the availability and quality of habitat for anadromous species above the dams, on watershed processes affected by the dams, and on the impact that dams may have on downstream habitat.

East Fork Lewis River

Access

- Assess and then prioritize replacement and/or repair a number of passage problems on McCormick, Brezee, Lockwood, Mason, Dean, and Manley Road Creeks.

Floodplain Connectivity

- Reconnect and enhance off-channel and floodplain habitats along the lower 10 miles of the East Fork to help increase limited rearing and over-wintering habitat for juvenile salmonids.
- Reconnection and restoration of small side channels and upwelling areas within the lower river will also be important to any future restoration plans for chum populations within the East Fork. The most dense observed spawning for chum salmon in the Lewis River basin historically occurred in side channels and upwelling areas in the lower 10 miles of the East Fork Lewis River (WDF 1973; Hawkins 1999, personal comm.)

Streambed Sediment Conditions

- Assess and, if possible, stabilize mass wasting and bank stability problems on the mainstem East Fork between RM 6 and RM 11. Excessive fine sediment is likely reaching critical fall chinook spawning areas in this stretch of the river.

- Also, assess and, if possible, stabilize mass wasting and bank instability problems on Mason Creek near Anderson Road Bridge, lower Rock Creek near Rock Creek Rd., and upper Rock Creek near Dole Valley Bridge.
- Assess sediment production from heavily traveled roads into Larch Mountain Corrections Facility, and look for solutions that will reduce sediment inputs to streams.

Channel Conditions

- Assess LWD concentrations and determine where there would be appropriate areas to supplement LWD in the mainstem and within tributaries of the East Fork Lewis River. LWD concentrations are well below standards almost throughout the East Fork system, and the appropriate placement of LWD would help collect spawning gravels, enhance pool habitat, create habitat diversity and cover for salmonids, and stabilize channels.

The highest concentrations of spawning summer steelhead within the Forest Service lands on the upper East Fork occur from Sunset Falls to McKinley Creek on the mainstem. Side-channel and low-velocity habitats adjacent to these spawning sites are limited, and enhancement or creation of these habitats would help increase survival for emerging fry.

Riparian Conditions

- Replant degraded riparian areas with native conifers to help reduce sediment delivery to the streams, to provide shade and reduce water temperatures, and to speed recruitment of conifers for a future supply of LWD. To begin with, focus riparian restoration efforts along the more productive tributaries.

Water Quality

- Find ways, at the watershed level, to reduce water temperatures within the East Fork basin. Excessive water temperatures during the summer and early fall months continue to degrade salmonid habitat; even as far up the system as Sunset Falls (RM 32.7).
- Eliminate the direct connection between Dean Creek and Stordahl & Sons' gravel processing ponds. Water temperatures within the ponds are well above state standards, and can even reach potentially lethal temperatures at various times of the years. Reduce turbidity in discharge waters from the gravel processing ponds at Stordahl & Sons by using flocculants and/or filters to reduce the suspended sediments of wastewater released into Dean Creek.
- Waste-water from the Larch Mountain Corrections facility may also be degrading water quality in nearby Cedar Creek, and improvements may be necessary.
- Farming operations in Fargher Lake area might be contributing to water quality problems within the lower Rock Creek basin. State standards for water quality were exceeded in lower Rock Creek for DO, turbidity, and fecal coliform over an 20 month period from May 1991 through December 1992 (Hutton, 1995a). There is a need to

assess and then address the connection between farming operations and water quality problems in lower Rock Creek.

- Continue to monitor water temperatures within the Ridgefield Pits and develop both short- and long-term plans for restoration of the site.

Water Quantity

Look for ways to augment low summer and early fall flows within the system.

It is apparent the pronounced seasonality of precipitation distribution and the subsequent streamflow is significantly limiting fisheries habitat and hence potential fish production in the summer and early fall months in the East Fork Lewis River and its' tributary streams including McCormick Creek, Breeze Creek, Lockwood Creek, Mason Creek, upper and lower Rock Creeks, Yacolt Creek, and Gee Creek (Loranger 1999).

Additional Studies

- Assess mass wasting problems, stream channel conditions, water quality, and predation occurring upstream, within, and downstream of the Ridgefield Pits. All anadromous fish using upstream habitats as well as downstream migrants must navigate this highly dynamic and potentially lethal section of the river. Look for both short-term and long-term solutions that will restore proper functioning habitat in this section of the East Fork.
- Conduct physical surveys of stream reaches within the basin to collect information on site-specific habitat conditions and fish usage. Very little specific data was available that could help quantify habitat conditions within many of the tributaries to the East Fork. This information is necessary to better identify what truly is limiting production of salmonids within the basin.

HABITAT IN NEED OF PROTECTION

Recommendations

The WRIA 27 Technical Advisory Group (TAG) had some difficulty narrowing down specific areas within the various basins that contained habitats in need of protection, mainly because the entire basin provides important habitat for some species during some life-history phase. What occurs upstream of these critical habitats also has direct bearing on the quality of the habitat downstream. However, there are general areas within each basin that provide especially important habitat during various life-history stages for coho, chum, chinook, and steelhead.

Kalama River

- The mainstem Kalama between Lower Kalama Falls (RM 10) to around Modrow Bridge (RM 2.4) provides the entire available spawning habitat for fall chinook and chum populations in the Kalama basin.
- Winter steelhead historically depended almost entirely upon the lower mainstem Kalama and its' tributaries below Lower Kalama Falls (RM 10) for spawning and rearing habitat. With the industrial, residential, and hatchery development that has occurred within the lower basin there is less productive habitat available below the falls today. And, now that winter steelhead are passed above the lower falls, the upper mainstem Kalama River (RM 10 to RM 35) provides the most important spawning habitat for winter steelhead in the Kalama basin.
- The tributaries below Lower Kalama Falls provide the most important spawning and rearing habitat for coho salmon.
- Natural coho production within the basin is likely limited by the availability of off-channel rearing and over-wintering habitat within the basin, and any remaining off-channel habitat would be critical to protect and enhance for natural coho production.
- Five tributaries, Gobar Creek, Wildhorse Creek, North Fork Kalama, Langdon Creek, and Lakeview Peak Creek, and the upper mainstem are all considered important spawning and rearing habitat for "threatened" summer steelhead in the upper Kalama River basin.

Lower Lewis River (to Merwin Dam)

- Off-Channel habitat surrounding Eagle Island provides critical rearing habitat for juvenile fall chinook.
- The entire mainstem reach between Cedar Creek and Merwin Dam needs protection to assure healthy returns for the most important spawning population of wild fall chinook in the lower Columbia region.
- The Cedar Creek watershed provides the majority of spawning and rearing habitat left for coho, steelhead, and cutthroat trout in the North Fork system. Protection and enhancement of this basin is critical.
- Wetland complexes in the lower 2 miles of the South Fork Chelatchie Creek provide important overwintering and rearing habitat for coho salmon.

- The North Fork Chelatchie Creek contributes cool, clear water to Cedar Creek. Protection of the wetland complexes and springs in the upper reaches in section 10 should help maintain water quality in the Cedar Creek basin.
- All backwater slough areas above the Lewis River Salmon Hatchery provide spawning grounds for the few remaining chum salmon that return to the North Fork.
- The lower reaches of Johnson, Ross, Robinson, and Colvin creeks provide important spawning and rearing habitat for coho and sometimes winter steelhead.

Upper Lewis River (Above Merwin Dam)

- Rush Creek, Pine Creek, and Cougar Creek provide the only known spawning and rearing habitat for "Threatened" bull trout populations in the upper North Fork Lewis River. Pine Creek Flows through a large block of State Land and ANE Forestry Property, and most of Cougar Creek flows through Weyerhauser property. Rush Creek falls entirely within the National Forest boundaries. The cool water within Rush Creek provides appropriate habitat conditions for sensitive bull trout populations.

East Fork Lewis River

- Wetlands and associated off-channel habitats between RM 2 and RM 10 provide important rearing and overwintering habitat for coho juveniles. Evidence increasingly points to the importance of overwintering habitat as a limit on production of salmonid smolts in some stream systems, particularly in coastal areas (Reeves et al. 1991; Brown 1987). Agricultural and grazing activities, residential development, and surface mining and processing within the lower 10 miles of the East Fork have diked, drained, filled these habitats; significantly reducing the amount of over-wintering habitat and disconnecting the river from these areas.
- Protection of the entire valley floor in the lower floodplain (below RM 10) from additional development or surface mining will help maintain groundwater recharge, protect water quality, eliminate the chance of additional catastrophic avulsions into deep gravel mining pits, and protect the hyporheic zone. Maintaining fully functioning floodplain habitat within the East Fork is extremely important, especially considering the loss of floodplain habitat on the North Fork and the minimal amount of floodplain habitat available in the Kalama basin.
- The lower tributaries within the East Fork basin (McCormick, Brezee, Lockwood, Mason, Mill and lower Rock creeks) provide important spawning and rearing habitat for coho and winter steelhead populations.
- Protection and enhancement of riparian and instream habitat along the mainstem East Fork between RM 6.2 and RM 15, will help protect the major spawning and rearing areas for the "wild" fall chinook population in the East Fork.
- Side channels and upwelling areas (groundwater seeps and springs) in the lower 10 miles of the East Fork historically provided the most significant spawning areas for chum salmon in the Lewis River basin. Reconnection and enhancement of these side

channels and upwelling areas will be important to any efforts to restore East Fork chum populations. These areas of upwelling also provide thermal refuge for coho juveniles during both summer and winter months.

- Rock Creek (upper) was identified by the TAG as probably the most important tributary to protect within the East Fork watershed for production of wild winter steelhead. In general, the habitat within Rock Creek is functional and spawning surveys find the highest density of steelhead reds per stream mile of any of the East Fork's tributaries. Protection of this area is critical to the success of recovery efforts for steelhead within the basin.

- The upper mainstem of the East Fork above Sunset Falls (RM 32.7) provides the most significant spawning and rearing habitat and adult staging areas for summer steelhead.

DATA GAPS

The ability to determine what factors are limiting salmonid production, and to prioritize those factors within and between drainages, is limited by the current lack of specific habitat assessment data. Other than Forest Service lands, few areas within WRIA 27 have had systematic physical habitat assessments that would help quantify habitat condition and fish usage. This lack of data was especially apparent when the TAG began discussions on the smaller tributaries. Collecting this baseline data will be critical for developing effective recovery plans, for prioritizing future recovery efforts, and for monitoring the success of those efforts. The following list identifies specific areas where the collection of additional data could improve understanding of WRIA 27 habitat limiting factors.

Watershed Condition

Understanding how various processes are operating at the basin level would substantially benefit the analysis of habitat limiting factors. With an understanding and quantification of the hydrology, sediment input and transport, nutrient cycling, and vegetation structure of the basin it becomes possible to better understand the relationships and develop connections between specific land uses and subsequent changes in aquatic ecosystems. For example, at what level of impervious surface, road density and/or of timber harvest within a basin do peak flows increase to levels that significantly alter stream channels and sediment transport? Without this watershed-scale picture, we often attempt to treat the symptoms without understanding the disease, and our restoration efforts fail. Studies that would benefit the understanding of conditions within every major basin within WRIA 27 include:

- GIS analysis of the vegetation structure and composition of each basin;
- A Peak flow analysis examining hydrologic maturity, road networks, and percent of impervious surfaces;
- A sediment budget that describes input and transport within each basin; and
- The potential for LWD recruitment within the basin.

Distribution and Condition of Stocks

Information was generally lacking on the distribution and recent condition of almost all stocks within WRIA 27. Spawning ground and stream surveys only cover a limited amount of habitat within each basin. There is minimal data on fish distribution available for areas like the smaller tributaries and floodplain habitats. Conducting additional fish surveys on smaller tributaries would provide a better picture of what habitat is being used and to what extent, and help identify where habitat may be limited.

Recent data on the condition of most stocks is also lacking. Data was last collected for the condition of salmon stocks in Columbia River as part of the SASSI report in 1992, and for steelhead stocks as part of the LCSCI in 1997. Updated information on the status of wild stocks will be critical for both focusing restoration efforts and monitoring the success of the restoration efforts. It will be important to monitor stock status, by maintaining, or if possible expanding ongoing trapping efforts and carcass and red surveys.

Access

The dams on the Lewis River represent the major access problem within WRIA 27, and it will be important that the relicensing process continue to explore methods to reintroduce anadromous fish above the dams. For other blockages there is now a fairly comprehensive database that exists on culverts under state and county roads within WRIA 27. However, the same methodologies were not used for all of the culvert inventories, knowledge of the habitat conditions both upstream and downstream of the blockage is limited, and many of the private culverts that may block passage along these stream systems have not be identified. With these data gaps it is difficult to prioritize repair and removal of blocking culverts.

Using just the number of miles of blocked habitat, the most important blockages to collect additional information on include:

- Brezee, McCormick, Mason, and Dean creeks on the East Fork Lewis River;
- Colvin Creek on the Lewis River;
- Beaver Creek, Bitter Creek, and Unnamed Creek (RM 10.3) on Cedar Creek;
- Potential low-flow and thermal passage barriers at the mouth of the Kalama River.
- Habitat and access conditions on Schoolhouse and Bybee Creeks.

Floodplain Connectivity

Very little floodplain habitat remains within the lower rivers of WRIA 27. The TAG identified some areas within the lower East Fork where dikes could possibly be removed and floodplain habitat reconnected; however, specific information on floodplain conditions in the lower Kalama and Lewis River basins was generally lacking.

Streambed Sediment Conditions

There was a general lack of information on streambed sediment conditions in WRIA 27. The most comprehensive data available was collected on Forest Service lands. Other than a few specific reaches data was either completely lacking on sediment conditions or we had a qualitative estimate by TAG members familiar with the stream system. There are a few general areas where physical surveys of sediment conditions would be especially important including;

- Lockwood, Mason, Dean, Lower Rock Creek, and Cedar Creeks on the East Fork;
- Cedar Creek and its major tributaries, and Robinson and Houghton Creeks on the Lewis River;
- Excessive sediment deposits at the mouth of the Kalama River and on many of its upper tributaries (Langdon, North Fork Kalama, Jacks, and Wolf Creeks).
- Wildhorse, Gobar, Arnold, Langdon, and Lakeview Peak creeks on the Kalama River.

Channel Conditions

Specific data on channel conditions within many of the streams within WRIA 27 was also lacking. Watershed Analyses from the Forest Service again provided the most comprehensive data, except that this data is generally only available within the upper portions of the basins. Specific areas that need additional study include:

- Between RM 12 and RM 6 on the East Fork Lewis to assess the apparently significant amount of erosion occurring within this reach;
- Channel conditions on the Kalama that may be contributing to the building of the shallow bar at the mouth;
- Channel conditions within the tributaries to the Kalama that have led to excessive deposits of gravels near their mouths;
- LWD debris abundance in the most productive tributaries within WRIA 27 including, Gobar, North Fork Kalama, Langdon, Arnold, and lakeView Peak creeks on the Kalama River; Lockwood, Mason, Cedar and upper Rock creeks on the East Fork Lewis River; and Cedar Creek and its tributaries on the Lewis River.

Riparian Conditions

A very generalized assessment of riparian conditions within most of WRIA 27 was provided with this report. However, there are specific areas where physical surveys could add significantly to the assessment. The greatest impacts to riparian habitat in WRIA have generally occurred along tributaries to the Kalama. Surveys of riparian conditions along these streams could help identify the most significant problem areas.

Water Quality

Water quality data within WRIA 27 is spotty, with very little information available for most of the tributaries to the main rivers. Without comprehensive coverage of all systems within the WRIA, it is difficult to pull together a picture of what types of problems are occurring and where. Water quality problems are generally no longer associated with point sources of pollution, but are now more a matter of cumulative impacts from a number of land uses across the landscape. Identifying the relationships between specific land uses and associated water quality problems and then finding solutions to these problems, requires an extensive and ongoing monitoring program.

At least within the East Fork, fecal coliform was the most widely spread water quality problem measured in the basin. While there is no direct linkage between fecal coliform and salmonid survival, the data can be used as an indicator of other problems in the watershed (animal access, septic failures, bank instability, high nutrient loads, etc.). Stream reaches with high fecal coliform counts should be assessed for associated physical habitat conditions that may limit salmonid productivity.
Elevated stream temperatures are consistent problems on the East Fork Lewis and many of its tributaries, on Cedar Creek, and at least on the lower 10 miles of the Kalama River. There may also be other area within the WRIA with significant problems that haven't as yet been monitored. Once again, the main reason for these high temperatures appears to be cumulative impacts from upstream sources. Additional water quality monitoring would help to identify areas where stream temperatures are elevated and to identify potential land uses that contribute to the problems. This may be the only way to begin to address water quality issues at both the site specific and watershed level.

One major problem with the existing water quality monitoring programs is that water quality standards are not necessarily based on the needs of fish, and restoration decisions based on these standards may not protect fish. It will be important to update water quality standards to assure protection of threatened and endangered fish species.

Water Quantity

The Department of Ecology, in cooperation with the Department of Fish and Wildlife, conducted an instream flow study on the East Fork and Kalama River and various tributaries to the East Fork and Lewis rivers. While the study identified the optimum flow for both spawning and rearing for various species, it did not identify flows necessary for incubation of fish eggs, smolt out-migration, fish passage to spawning grounds, and prevention of stranding fry and juveniles. Meeting these needs is required when setting minimum instream flows. Nor did the study consider other variables such as, water temperature, water quality, and sediment load. The data from Ecology's study shows that low-flow is limiting rearing habitat for salmonid juveniles during the summer and fall months. These are also the times when elevated water temperatures stress juveniles rearing in already limited habitat. The combination of these factors needs additional research to determine the impacts to fish that must find suitable rearing habitat within fresh water year-round. It will be important to incorporate this additional information into the models before determining appropriate minimum instream flows.

Many of the stream gages that could provide critical information on stream flows are no longer in use. The TAG suggested that as many as possible of these gages be restored and monitored.

Habitats in Need of Protection

Identification of important habitats that needed protection was based on the collective knowledge of the TAG members. While the fisheries and habitat experts on a stream system are likely to identify the most critical habitats, it would be important to develop a standardized methodology for identifying these areas that could then be applied consistently across the region.

Additional data on the distribution and abundance of the various species during all life-history phases and on existing habitat conditions would also benefit the analysis of which habitats are truly the most critical to protect within each basin.

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APPENDIX B

Salmonid Habitat Condition Rating Standards for Identifying Limiting Factors

Under the Salmon Recovery Act (passed by the legislature as House Bill 2496, and later revised by Senate Bill 5595), the Washington Conservation Commission (WCC) is charged with identifying the habitat factors limiting the production of salmonids throughout most of the state. This information should guide lead entity groups and the Salmon Recovery Funding Board in prioritizing salmonid habitat restoration projects seeking state and federal funds. Identifying habitat limiting factors requires a set of standards that can be used to compare the significance of different factors and consistently evaluate habitat conditions in each WRIA throughout the state.

In order to develop a set of standards to rate salmonid habitat conditions, several tribal, state, and federal documents that use some type of habitat rating system (Table 30) were reviewed. The goal was to identify appropriate rating standards for as many types of limiting factors as possible, with an emphasis on those that could be applied to readily available data. Based on the review, it was decided to rate habitat conditions into three categories: Good, Fair, and Poor. For habitat factors that had wide agreement on how to rate habitat condition, the accepted standard was adopted by the WCC. For parameters that had a range of standards, one or more of them were adopted. Where no standard could be found, a default rating standard was developed, with the expectation that it will be modified or replaced as better data become available.

The ratings adopted by the WCC are presented in Table 31. These ratings are not intended to be used as thresholds for regulatary purposes, but as a coarse screen to identify the most significant limiting factors in a WRIA. They also will hopefully provide a level a consistency between WRIAs that allows habitat conditions to be compared across the state. However, for many habitat factors, there may not be sufficient data available to use a rating standard or there may be data on habitat parameters where no rating standard is provided. For these factors, the professional judgment of the TAG should be used to assign the appropriate ratings.

In some cases there may be local conditions that warrant deviation from the rating standards presented here. This is acceptable as long as the justification and a description of the procedures that were followed are clearly documented in the limiting factors report. Habitat condition ratings specific to streams draining east of the Cascade crest were included where they could be found, but for many parameters they were not. Additional rating standards will be included as they become available. In the meantime, TAGs in these areas will need to work with the standards presented here or develop alternatives based on local conditions. Again, if deviating from these standards, the procedures followed should be clearly documented in the limiting factors report.

Table 30 - Source Documents for Habitat Ratings

Code	Document	Organization
Hood Canal	Hood Canal/Eastern Strait of Juan de Fuca Summer Chum Habitat Recovery Plan, Final Draft (1999)	Point No Point Treaty Council, Skokomish Tribe, Port Gamble S'Klallam Tribe, Jamestown S'Klallam Tribe, and Washington Department of Fish and Wildlife
ManTech	An Ecosystem Approach to Salmnoid Conservation, vol. 1 (1995)	ManTech Environmental Research Services for the National Marine Fisheries Service, the US Environmental Protection Agency, and the US Fish and Wildlife Service
NMFS	Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast (1996)	National Marine Fisheries Service
PHS	Priority Habitat Management Recommendations: Riparian (1995)	Washington Department of Fish and Wildlife
Skagit	Skagit Watershed Council Habitat Protection and Restoration Strategy (1998)	Skagit Watershed Council
WSA	Watershed Analysis Manual, v4.0 (1997)	Washington Forest Practices Board
WSP	Wild Salmonid Policy (1997)	Washington Department of Fish and Wildlife

Table 31: Salmonid Habitat Condition Ratings

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Access and Passage						
Artificial Barriers	% known/potential habitat blocked by artificial barriers	All	>20%	10-20%	<10%	WCC
Floodplains						
Floodplain Connectivity	Stream and off-channel habitat length with lost floodplain connectivity due to incision, roads, dikes, flood protection, or other	<1% gradient	>50%	10-50%	<10%	WCC
Loss of Floodplain Habitat	Lost wetted area	<1% gradient	>66%	33-66%	<33%	WCC
Channel Conditions						
Fine Sediment	Fines < 0.85 mm in spawning gravel	All – Westside	>17%	11-17%	≤11%	WSP/WSA / NMFS/Hood Canal
	Fines < 0.85 mm in spawning gravel	All – Eastside	>20%	11-20%	≤11%	NMFS

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Large Woody Debris	pieces/m channel length	≤4% gradient, <15 m wide (Westside only)	<0.2	0.2-0.4	>0.4	Hood Canal/Skagit
	or use Watershed Analysis piece and key piece standards listed below when data are available					
	pieces/channel width	<20 m wide	<1	1-2	2-4	WSP/WSA
	key pieces/channel width*	<10 m wide (Westside only)	<0.15	0.15-0.30	>0.30	WSP/WSA
	key pieces/channel width*	10-20 m wide (Westside only)	<0.20	0.20-0.50	>0.50	WSP/WSA
	* Minumim size to qualify as a key piece:	BFW (m): 0-5 6-10 11-15 16-20	Diameter (m): 0.4 0.55 0.65 0.7	Length (m): 8 10 18 24		
Percent Pool	% pool, by surface area	<2% gradient, <15 m wide	<40%	40-55%	>55%	WSP/WSA
	% pool, by surface area	2-5% gradient, <15 m wide	<30%	30-40%	>40%	WSP/WSA
	% pool, by surface area	>5% gradient, <15 m wide	<20%	20-30%	>30%	WSP/WSA
	% pool, by surface area	>15 m	<35%	35-50%	>50%	Hood Canal

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Pool Frequency	channel widths per pool	<15 m	>4	2-4	<2	WSP/WSA
	channel widths per pool	>15 m	-	-	chann width / pools/ mile / cw/ pool 50' 26 4.1 75' 23 3.1 100' 18 2.9	NMFS
Pool Quality	pools >1 m deep with good cover and cool water	All	No deep pools and inadequate cover or temperature, major reduction of pool volume by sediment	Few deep pools or inadequate cover or temperature, moderate reduction of pool volume by sediment	Sufficient deep pools	NMFS/WSP/WSA
Streambank Stability	% of banks not actively eroding	All	<80% stable	80-90% stable	>90% stable	NMFS/WSP
Sediment Input						
Sediment Supply	$m^3/km^2/yr$	All	> 100 or exceeds natural rate*	-	< 100 or does not exceed natural rate*	Skagit
	* Note: this rate is highly variable in natural conditions					
Mass Wasting		All	Significant increase over natural levels for mass wasting events that deliver to stream	-	No increase over natural levels for mass wasting events that deliver to stream	WSA
Road Density	mi/mi^2	All	>3 with many valley bottom roads	2-3 with some valley bottom roads	<2 with no valley bottom roads	NMFS
	or use results from Watershed Analysis where available					

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Riparian Zones						
Riparian Condition	riparian buffer width (measured out horizontally from the channel migration zone on each side of the stream) riparian composition	Type 1-3 and untyped salmonid streams >5' wide	<75' or <50% of site potential tree height (whichever is greater) OR Dominated by hardwoods, shrubs, or non-native species (<30% conifer) unless these species were dominant historically.	75'-150' or 50-100% of site potential tree height (whichever is greater) AND Dominated by conifers or a mix of conifers and hardwoods (≥30% conifer) of any age unless hardwoods were dominant historically.	>150' or site potential tree height (whichever is greater) AND Dominated by mature conifers (≥70% conifer) unless hardwoods were dominant historically	WCC/WSP
	buffer width riparian composition	Type 4 and untyped perennial streams <5' wide	<50' with same composition as above	50'-100' with same composition as above	>100' with same composition as above	WCC/WSP
	buffer width riparian composition	Type 5 and all other untyped streams	<25' with same composition as above	25'-50' with same composition as above	>50' with same composition as above	WCC/WSP
Water Quality						
Temperature	degrees Celsius	All	>15.6° C (spawning) >17.8° C (migration and rearing)	14-15.6° C (spawning) 14-17.8° C (migration and rearing)	10-14° C	NMFS

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Dissolved Oxygen	mg/L	All	<6	6-8	>8	ManTech

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Hydrology						
Flow	hydrologic maturity	All	<60% of watershed with forest stands aged 25 years or more	-	>60% of watershed with forest stands aged 25 years or more	WSP/Hood Canal
		or use results from Watershed Analysis where available				
	% impervious surface	Lowland basins	>10%	3-10%	≤3%	Skagit
Biological Processes						
Nutrients (Carcasses)	***Number of stocks meeting escapement goals***	***All Anadromous***	***Most stocks do not reach escapement goals each year***	***Approximately half the stocks reach escapement goals each year***	***Most stocks reach escapement goals each year***	***WCC***
Lakes (further work needed)						
Estuaries – See Table 32 Below						

Table 32. System for Rating Estuarine Habitat Conditions

		Aquatic Conditions	
		1- % Historic Marsh Remaining	< 25%
		2- % Mainstem Channel Habitat Lost	> 50%
		3- % Non-Mainstem Habitat Lost	> 75%
		4- % Estuary Disconnected From Floodplain	> 75%
		5- % Covered by Aquatic Exotic Plants	> 25%
		6- Hydrology (Amount of Water Arriving In Estuary)	
		Only one score depending on whether there has been a net increase or decrease	> 50%
			> 50%
		7- Hydrology (% Deviation From Natural Flow Patterns)	Large
		8- Water quality (Subjective)	Poor
		Overall Zone Rating	
		Good	73-100
		Fair	48-72
		Poor	20-47
Nearshore Marine	Zone bounded by the edge of the delta to the boundary of the photic zone and continuing along the shore to a point halfway to the next estuary.	% Diked or Bulkheaded	> 66%
		Docks/km of Shoreline	> 10
		% Intact Riparian Zone	< 25%
		% Covered by Exotic Aquatic Plants	> 25%
		Overall Zone Rating	
		Good	19 to 25
		Fair	12 to 18
		Poor	5 to 11
			Small
		Overall Estuary Rating	
		Good	**92-125**
		Fair	**60-91**
		Poor	**25-59**

Notes: See Summer Chum Report from Hood Canal
Consider this a first order approximation
Vegetation zones will need to be more precisely defined but they should be more or less delineated in a field da

Rating of Estuarine Habitat Conditions									
All Values are Referenced to Historic Conditions of Estuary which is defined as both wetted and upland area.									
The following system can be applied for both large and small estuaries.									
Large Estuaries are defined as an estuary where the area of Zone 1 and 2 combined is greater than approximately 2.0 sq miles									
For large estuaries, treat zone 1, 2 and 3 seperately. For small estuaries, treat zone 1 and 2 as one area combined.									
	Zone Characteristics	Parameter	Poor		Fair		Good		
Upper	FW tidal to brackish marsh area.	**Upland Condition**							
	Zone is delineated mostly by vegetatio	1- % Developed lands (Non Agricultural, Non Vegetate	> 50%	1	25-50%	3	< 25%	5	Within historic estuary area.
	Dominant vegetation type is Carex.	2- % Agricultural lands	> 75%	1	50-75%	3	< 50%	5	
	Ranges down to where Fucus and	3- % Forested uplands	< 25%	1	25-50%	3	> 50%	5	
	Salnicornia become prevelant and	4- % Historic Floodplain Wetlands Remaining	< 25%	1	25-50%	3	> 50%	5	Mostly unconnected, non marsh areas.
	Carex is sparse.								
		Aquatic Conditions							
		1- % Historic Marsh Remaining	< 25%	2	25-50%	6	> 50%	10	Marsh only
		2- % Mainstem Channel Habitat Lost	> 50%	2	25-50%	6	< 25%	10	Reflects loss of sinuosity
		3- % Non-Mainstem Habitat Lost	> 75%	2	25-50%	6	< 25%	10	Sloughs, off channel areas
		4- % Estuary Disconnected From Floodplain	> 75%	2	25-50%	6	< 25%	10	Disconnected from floodplain
		5- % Covered by Aquatic Exotic Plants	> 25%	2	10-25%	6	< 10%	10	Primarily Spartina
		6- Hydrology (Amount of Water Arriving In Estuary)							
		Only one score depending on whether there has	> 50%	2	10-50%	6	<10%	10	% Reduction in Average Annual Flow
		been a net increase or decrease			OR				
			> 50%	2	10-50%	6	<10%	10	% Increase in Average Annual Flow
		7- Hydrology (% Deviation From Natural Flow Patterns	Large	2	Medium	6	High	10	Subjective rating
		8- Water quality (Subjective)	Poor	2	Fair	6	Good	10	Subjective rating
		Overall Zone Rating							
		Good	73-100						
		Fair	48-72						
		Poor	20-47						
Lower	Brackish Marsh to delta face.	**Upland Condition**							
	Zone is delineated mostly by vegetatio	1- % Developed lands (Non Agricultural, Non Vegetate	> 50%	1	25-50%	3	< 25%	5	Within historic estuary area.
	Dominant vegetation type is Fucus	2- % Agricultural lands	> 75%	1	50-75%	3	< 50%	5	
	and Salnicornia. Zone stops along	3- % Forested uplands	< 25%	1	25-50%	3	> 50%	5	
	shore where these marsh plant stops.	4- % Historic Floodplain Wetlands Remaining	< 25%	1	25-50%	3	> 50%	5	Mostly unconnected, non marsh areas.

APPENDIX C

Fish Distribution Definitions:

KNOWN

Habitat that is documented to presently sustain fish populations (published sources, survey notes, first-hand sightings, etc.): or, habitat with records of fish use (which may or may not be known to have been extirpated for some reason). This includes habitat used by all life history stages for any length of time (i.e. intermittent streams which contain water during flood flows that provides refuge habitat for a period of hours or days).

PRESUMED

Habitat with no records of known fish use, but that is below any known natural barrier (including sustained 12% gradient) and otherwise conforms to species-specific habitat criteria.

POTENTIAL

Habitat above human-caused blockages or obstructions that could be opened to fish use and that is below any known natural barrier (including sustained 12% gradient) and otherwise conforms to species-specific habitat criteria.

GLOSSARY

Adaptive management: Monitoring or assessing the progress toward meeting objectives and incorporating what is learned into future management plans.

Adfluvial: Life history strategy in which adult fish spawn and juveniles subsequently rear in streams but migrate to lakes for feeding as subadults and adults. Compare fluvial.

Aggradation: The geologic process of filling and raising the level of the streambed or floodplain by deposition of material eroded and transported from other areas.

Anadromous fish: Species that are hatched in freshwater mature in saltwater, and return to freshwater to spawn.

Aquifer: Water-bearing rock formation or other subsurface layer.

Basin: The area of land that drains water, sediment and dissolved materials to a common point along a stream channel.

Basin flow: Portion of stream discharge derived from such natural storage sources as groundwater, large lakes, and swamps but does not include direct runoff or flow from stream regulation, water diversion, or other human activities.

Bioengineering: Combining structural, biological, and ecological concepts to construct living structures for erosion, sediment, or flood control.

Biological Diversity (biodiversity): Variety and variability among living organisms and the ecological complexes in which they occur; encompasses different ecosystems, species, and genes.

Biotic Integrity: Capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region; a system's ability to generate and maintain adaptive biotic elements through natural evolutionary processes.

Biological oxygen demand: Amount of dissolved oxygen required by decomposition of organic matter.

Braided stream: Stream that forms an interlacing network of branching and recombining channels separated by branch islands or channel bars.

Buffer: An area of intact vegetation maintained between human activities and a particular natural feature, such as a stream. The buffer reduces potential negative impacts by providing an area around the feature that is unaffected by this activity.

Carrying capacity: Maximum average number or biomass of organisms that can be sustained in a habitat over the long term. Usually refers to a particular species, but can be applied to more than one.

Channelization: Straightening the meanders of a river; often accompanied by placing riprap or concrete along banks to stabilize the system.

Channelized stream: A stream that has been straightened, runs through pipes or revetments, or is otherwise artificially altered from its natural, meandering course.

Channel Stability: Tendency of a stream channel to remain within its existing location and alignment.

Check dams: Series of small dams placed in gullies or small streams in an effort to control erosion. Commonly built during the 1900s.

Confluence: Joining.

Connectivity: Unbroken linkages in a landscape, typified by streams and riparian areas.

Critical Stock: A stock of fish experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred.

Depressed Stock: A stock of fish whose production is below expected levels based on available habitat and natural variations in survival levels, but above the level where permanent damage to the stock is likely.

Debris torrent: Rapid movements of material, including sediment and woody debris, within a stream channel. Debris torrents frequently begin as debris slides on adjacent hillslopes.

Degradation: The lowering of the streambed or widening of the stream channel by erosion. The breakdown and removal of soil, rock and organic debris.

Deposition: The settlement of material out of the water column and onto the streambed.

Distributaries: Divergent channels of a stream occurring in a delta or estuary.

Diversity: Variation that occurs in plant and animal taxa (i.e., species composition), habitats, or ecosystems. See species richness.

Ecological restoration: Involves replacing lost or damaged biological elements (populations, species) and reestablishing ecological processes (dispersal, succession) at historical rates.

Ecosystem: Biological community together with the chemical and physical environment with which it interacts.

Ecosystem management: Management that integrates ecological relationships with sociopolitical values toward the general goal of protecting or returning ecosystem integrity over the long term.
Endangered Species Act: A 1973 Act of Congress that mandated that endangered and threatened species of fish, wildlife and plants be protected and restored.

Endangered Species: Means any species which is in endanger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta as determined by the Secretary to constitute a pest whose protection under would provide an overwhelming and overriding risk to man.

Escapement: Those fish that have survived all fisheries and will make up a spawning population.

Estuarine: A partly enclosed coastal body of water that has free connection to open sea, and within which seawater is measurably diluted by fresh river water.

Eutrophic: Water body rich in dissolved nutrients, photosynthetically productive, and often deficient in oxygen during warm periods. Compare oligotrophic.

Evolutionary Significant Unit (ESU): A definition of a species used by National Marine Fisheries Service (NMFS) in administering the Endangered Species Act. An ESU is a population (or group of populations) that is reproductively isolated from other conspecific population units, and (2) represents an important component in the evolutionary legacy of the species.

Extirpation: The elimination of a species from a particular local area.

Flood: An abrupt increase in water discharge.

Floodplain: Lowland areas that are periodically inundated by the lateral overflow of streams or rivers.

Flow regime: Characteristics of stream discharge over time. Natural flow regime is the regime that occurred historically.

Fluvial: Pertaining to streams or rivers; also, organisms that migrate between main rivers and tributaries. Compare adfluvial.

Gabion: Wire basket filled with stones, used to stabilize streambanks, control erosion, and divert stream flow.

Genetic Diversity Unit (GDU) is defined as: A group of genetically similar stocks that is genetically distinct from other such groups. The stocks typically exhibit similar life histories and occupy ecologically, geographically and geologically similar habitats. A GDU may consist of a single stock

Geomorphology: Study of the form and origins of surface features of the Earth.

Glides: Stream habitat having a slow, relatively shallow run of water with little or no surface turbulence.

Healthy Stock: A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.
Hydrograph: Chart of water levels over time.

Hydrology: Study of the properties, distribution, and effects of water on the Earth's surface, subsurface, and atmosphere.

Intermittent stream: Stream that has interrupted flow or does not flow continuously. Compare perennial stream.

Intraspecific interactions: Interactions within a species.

Large Woody Debris (LWD): Large woody material that has fallen to the ground or into a stream. An important part of the structural diversity of streams. LWD is also referenced to as "coarse woody debris" (CWD). Either term usually refers to pieces at least 20 inches (51 cm) in diameter.

Limiting Factor: Single factor that limits a system or population from reaching its highest potential.

Macroinvertebrates: Invertebrates large enough to be seen with the naked eye (e.g., most aquatic insects, snails, and amphipods).

Mass failure: Movement of aggregates of soil, rock and vegetation down slope in response to gravity.

Native: Occurring naturally in a habitat or region; not introduced by humans.

Non-Point Source Pollution: Polluted runoff from sources that cannot be defined as discrete points, such as areas of timber harvesting, surface mining, agriculture, and livestock grazing.

Parr: Young trout or salmon actively feeding in freshwater; usually refers to young anadromous salmonids before they migrate to the sea. See smolt.

Plunge pool: Basin scoured out by vertically falling water.

Rain-on-snow events: The rapid melting of snow as a result of rainfall and warming ambient air temperatures. The combined effect of rainfall and snow melt can cause high overland stream flows resulting in severe hillslope and channel erosion.

Rearing habitat: Areas required for the successful survival to adulthood by young animals.

Recovery: The return of an ecosystem to a defined condition after a disturbance.

Redds: Nests made in gravel (particularly by salmonids); consisting of a depression that is created and the covered.
Resident fish: Fish species that complete their entire life cycle in freshwater.

Riffle: Stream habitat having a broken or choppy surface (white water), moderate or swift current, and shallow depth.

Riparian: Type of wetland transition zone between aquatic habitats and upland areas. Typically, lush vegetation along a stream or river.

Riprap: Large rocks, broken concrete, or other structure used to stabilize streambanks and other slopes.

Rootwad: Exposed root system of an uprooted or washed-out tree.

SASSI: Salmon and Steelhead Stock Inventory.

SSHIAP: A salmon, steelhead, habitat inventory and assessment program directed by the Northwest Indian Fisheries Commission.

Salmonid: Fish of the family salmonidae, including salmon, trout chars, and bull trout.

Salmon: Includes all species of the family Salmonid

Sediment: Material carried in suspension by water, which will eventually settle to the bottom.

Sedimentation: The process of sediment being carried and deposited in water.

Side channel: A portion of an active channel that does not carry the bulk of stream flow. Side channels may carry water only during high flows, but are still considered part of the total active channel.

Sinuosity: Degree to which a stream channel curves or meanders laterally across the land surface.

Slope stability: The degree to which a slope resists the downward pull of gravity.

Smolt: Juvenile salmon migrating seaward; a young anadromous trout, salmon, or char undergoing physiological changes that will allow it to change from life in freshwater to life in the sea. The smolt state follows the parr state. See parr.

Stock: Group of fish that is genetically self-sustaining and isolated geographically or temporally during reproduction. Generally, a local population of fish. More specifically, a local population – especially that of salmon, steelhead (rainbow trout), or other anadromous fish – that originates from specific watersheds as juveniles and generally returns to its birth streams to spawn as adults.

Stream order: A classification system for streams based on the number of tributaries it has. The smallest unbranched tributary in a watershed is designated order 1. A stream formed by the confluence of 2 order 1 streams is designated as order 2. A stream formed by the confluence of 2 order 2 streams is designated order 3, and so on.

Stream reach: Section of a stream between two points.

Stream types:
Type 1: All waters within their ordinary high-water mark as inventoried in "Shorelines of the State".
Type 2: All waters not classified as Type 1, with 20 feet or more between each bank's ordinary high water mark. Type 2 waters have high use and are important from a water quality standpoint for domestic water supplies, public recreation, or fish and wildlife uses.
Type 3: Waters that have 5 or more feet between each bank's ordinary high water mark, and which have a moderate to slight use and are more moderately important from a water quality standpoint for domestic use, public recreation and fish and wildlife habitat.
Type 4: Waters that have 2 or more feet between each bank's ordinary high water mark. Their significance lies in their influence on water quality of larger water types downstream. Type 4 streams may be perennial or intermittent.
Type 5: All other waters, in natural water courses, including streams with or without a well-defined channel, areas of perennial or intermittent seepage, and natural sinks. Drainage ways having a short period of spring runoff are also considered to be Type 5.

Sub Watershed: One of the smaller watersheds that combine to form a larger watershed.

Thalweg: Portion of a stream or river with deepest water and greatest flow.

Watershed: Entire area that contributes both surface and underground water to a particular lake or river.

Watershed rehabilitation: Used primarily to indicate improvement of watershed condition or certain habitats within the watershed. Compare watershed restoration.

Watershed restoration: Reestablishing the structure and function of an ecosystem, including its natural diversity; a comprehensive, long-term program to return watershed health, riparian ecosystems, and fish habitats to a close approximation of their condition prior to human disturbance.

Watershed-scale approach: Consideration of the entire watershed in a project or plan.

Weir: Device across a stream to divert fish into a trap or to raise the water level or divert its flow. Also a notch or depression in a dam or other water barrier through which the flow of water is measured or regulated.

Wild Stock: A stock that is sustained by natural spawning and rearing in the natural habitat regardless.